WHEWELL'S
Philosophy of Induction

By

Marion Rush Stoll

Submitted to the Faculty of Bryn Mawr College
in Partial Fulfillment of the Requirements for
the Degree of Doctor of Philosophy

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PREFACE.

The philosophy of induction which William Whewell developed represents a sustained effort on the part of a careful critic to deduce an epistemology and a theory of scientific method from a survey of the development of the inductive sciences up to his own time. The present review of Whewell's philosophy aims not only to give a brief exposition of his ideas and to indicate their more or less serious limitations, but also to call attention to certain fundamental difficulties to which the various traditional types of logical theory are liable. Shadows of those same difficulties overhang recent, more sophisticated developments of the diverse points of view. Whewell's philosophy may be outgrown, but the difficulties with which he labored are not yet conquered, and much may be learned from his wrestlings with them.

The never-failing interest and helpful criticism of Dr. Theodore de Laguna, under whose direction this dissertation has been written, have made its preparation a pleasant task. It has been made easier, too, by the courtesies of the librarians of the University of Michigan.

M. R. S.

BALTIMORE, MARYLAND,
October 2, 1929.

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CHAPTER I.

Introduction.

Just after the close of the first third of the nineteenth century, William Whewell, then a Fellow at Trinity College, Cambridge, outlined in a letter to a friend his plan for writing a history and philosophy of the inductive sciences.[1] The first part of the undertaking was accomplished in 1837, when Whewell's *History of the Inductive Sciences from the earliest to the present time* was presented to the English public. In this three volume work, Whewell gave an account of the historical development of each of the inductive sciences which in his day seemed to be grounded in certain, basic truths. He included in his survey histories of astronomy, physics, chemistry, botany, zoology, and geology, discussing also various subdivisions of these sciences. He began with a critical review of the scientific thought of ancient Greece. He considered the contributions made in the middle ages by the schoolmen and by the Arabians. Then he proceeded to complete a detailed account of the development of each of the physical sciences up to his own time.

Whewell presented this historical material in a form which gives it a certain dramatic character. According to Whewell, each great period of advance has culminated in the discovery of some general relating idea or conception which is expressed in the form of a law. Preliminary investigation, contributing the observation

[1] Cf. I. Todhunter, *William Whewell, D.D.*, Vol. I, p. 90. This work is frequently referred to below as IT.

The following abbreviations are also used:

BT..... Whewell's *Bridgewater Treatise, Astronomy and General Physics considered with Reference to Natural Theology.*

HIS.... Whewell's *History of the Inductive Sciences from the earliest to the present time,* 3d English ed., 1857.

HSI.... Whewell's *History of Scientific Ideas,* 1858.

ME..... Whewell's *The Mechanical Euclid.*

NOR... Whewell's *Novum Organon Renovatum,* 1858.

PD..... Whewell's *Philosophy of Discovery,* 1860.

Roman numerals indicate the volume; Arabic, the pages.

of particular facts, provides the basis for this further advance. The preparatory period which leads up to discovery Whewell termed the " Prelude to Discovery." The " Epoch of Induction " which follows is marked by the discovery and establishment of a new generalization which includes previous discoveries and brings them into connection with one another. For instance, Copernicus' demonstration of the heliocentric theory and Kepler's discovery of the laws of motion of the planets mark epochs of induction in the history of formal astronomy, and Newton's theory of gravitation marks a similar epoch in the later development of physical astronomy, according to Whewell's classification. These periods of discovery are characteristically followed by periods of development and application of the new theories. Whewell referred to these last as " Sequels to Discovery." [2] In the *History,* Whewell represented each advance of major importance as marking an inductive epoch in the development of a particular science, while he assigned subsidiary discoveries to their appropriate places in the preludes or sequels to discovery. This scheme provided a means of emphasizing the contributions to the various sciences in careful accordance with their relative significance. It also provided for organizing the material in such a way that it could readily be referred to for evidence in support of Whewell's philosophy as presented in *The Philosophy of the Inductive Sciences, founded upon their History.* Finally, this mode of presentation made of the *History* a varied and interesting narrative. As one critic said, Whewell's *History* was actually *readable,* while others were merely *consulted.*[3] The *History* did in fact have wide circulation for a work of its kind and price,[4] and it has always been more popular than the *Philosophy* which was based upon it.

The *History* presented accurate accounts of all the assured progress that had been made in science up to Whewell's time. It was Whewell's purpose also to include accounts of contemporary advances. Two difficulties arose in connection with this last effort. Of the first of these Whewell was fully conscious: he attempted the delicate task of evaluating the contributions of his contemporaries to the progress of their chosen sciences. It was impossible that he should satisfy everyone, but on the whole he

[2] Cf. *History of the Inductive Sciences,* Introduction, p. 9 ff.

[3] J. D. Forbes, *Fraser's Magazine,* March, 1858. Vol. 57, pp. 283–294.

[4] Cf. Mrs. Stair-Douglas, *The Life of William Whewell,* p. 189.

seemed to convince most people of the sincerity of his effort and the fairness of his judgments. One irritable critic did accuse Whewell of willful neglect of the claims of the Scotch nation,[5] but his charge was contradicted by another Scotchman who wrote after the publication of the third edition of the *History*. In a review which appeared in *Fraser's Magazine*,[6] Professor Forbes applauded Whewell's success in his attempt to prepare an accurate history of each of the inductive physical sciences, remarking that Whewell's refusal to concentrate his efforts in any single field of science was probably one circumstance contributing to his success. He added that in his opinion Whewell had succeeded fairly well in doing for contemporary science what the progress of thought had done for earlier contributions, for Whewell selected for attention only those contributions which seemed destined to direct the course of future advance, and he left to comparative obscurity those which would probably be incorporated into wider generalizations. Unfortunately, however, Whewell could not always foresee the importance which posterity would attribute to some of the theories proposed by his contemporaries.

This suggests the second difficulty with which Whewell had to contend. The nineteenth century was a time of rapid advance in the progress of science. Many discoveries were being made while Whewell was preparing the *History*, and some were published very soon after Whewell's volumes appeared. Helmholtz published his essay on the conservation of energy in 1847, ten years after the publication of the first edition of Whewell's *History*. The views so clearly expressed by Helmholtz initiated changes in the science of physics which soon made Whewell's account of its development inadequate.[7] Lyell's *Principles of Geology* had been published

[5] Sir David Brewster, *Edinburgh Review*, 1837. Vol. 66, No. 133, pp. 110–157.

[6] J. D. Forbes, *Fraser's Magazine*, March, 1858. Vol. 57, pp. 283–294.

[7] In an unsigned German article published in 1866 in *Unsere Zeit*, N. S. 2, part I, pp. 839–859, Whewell is lauded for his appreciation of the discovery of the mechanical equivalent of heat. Credit is also attributed to him for making precise experimental determinations of the quantitative relations between heat and energy. Apparently, the reviewer confused Whewell with Joule, whose name might easily be confused with Whewell's if given a German pronunciation. Whewell actually said very little on the point for which the reviewer commends him. A chapter of a page and a half, added in the third edition of the *History*, Vol. II, p. 487, and a suggestion that the law

before Whewell wrote, and had been reviewed by Whewell in 1831.[8] The correctness of Lyell's theory of uniformitarianism had not yet been generally recognized. Whewell expressed a pious preference for the catastrophic theories which were eventually supplanted by Lyell's views, and he repeated his arguments in the *History*. (HIS, III, 506 ff.) Darwin's *Origin of Species* was published only after the third and final edition of the *History* had appeared in 1857. This fact excuses Whewell's enthusiasm for Cuvier's belief in the fixity of species and in the doctrine of final causes, and it excuses also his hostile criticism of St. Hilaire's opposing views. Whewell's discussion indicated, however, that he would not easily accept the theories which Darwin and Wallace announced. As a matter of fact, he opposed Darwin's views when they did appear by denying to the *Origin of Species* a place in the library of Trinity College, of which he was then Master.[9]

It was unfortunate that the accounts in the *History of the Inductive Sciences* very soon needed revision as a consequence of the appearance of the new theories. Some of these most recent advances should certainly have been mentioned in the second and third editions of the *History*. Whewell neglected to undertake the necessary revision and contented himself with writing "additions" to various chapters. Whewell may have believed that the *History* had fulfilled its function as a preparation for the *Philosophy*, and since he had "in some measure wound up his account with physical science," [10] he was reluctant to undertake the labor which adequate revision would involve. Whewell could not foresee that the *History*, so obviously limited by the accident of its appearing just too early to take account of many advances of major importance, would save its author from oblivion when his *Philosophy of the Inductive Sciences* had been generally forgotten.

The *History* is still frequently frequently referred to, not only because it is an authentic account of the development of the various inductive sciences up to Whewell's time, but also because it is the only English work so comprehensive in its scope. Whewell's effort was one of the first attempts in modern times to survey the

of the conservation of force might come to be regarded as a fundamental truth of physics (PD, 348), represent his actual contributions on this point.

[8] *British Critic*, January, 1831. No. 17, pp. 180–206.

[9] Cf. F. Darwin, *Life and Letters of Charles Darwin*, Vol. II, p. 55, note.

[10] Cf. IT, II, 287.

history of the inductive sciences, and more recent writers have not pretended to so vast a range of knowledge as Whewell's undertaking required. The great advances of recent times appear to have extended the developments of science beyond the limits of any one individual's grasp.

Whewell was peculiarly well prepared for the task which he had set himself. Although he first distinguished himself in classics and mathematics, he seems to have had an eager interest in the progress of the physical sciences during his undergraduate days.[11] In his more mature years, Whewell could claim acquaintance with the general developments in all of the physical sciences and he could speak with authority in regard to many of them. He counted among his personal friends Herschel, Lyell, Faraday, and others who were contributing to contemporary progress in the different sciences. Through his associations with men like these, Whewell was encouraged to keep abreast of the tide of scientific progress even in fields which he did not claim as his own. Moreover, Whewell was actively interested in the progress of the social sciences and in the development of moral theory. This breadth of interest won him the reputation of possessing more universal knowledge than any man in England. Frequent repetition of Sydney Smith's quip: "Science is his forte; omniscience his foible," testified to the general appreciation of his extensive learning.

Whewell is to be credited with many contributions to science of a sort more direct than those represented in the writing of the *History* and the *Philosophy*. He was one of those who was instrumental in bringing about the establishment of a natural science tripos at Cambridge, and he was also a zealous advocate of the plan for requiring some knowledge of physics from all who presented themselves for examination for degrees. It was partly due to Whewell's influence that Cambridge became known as the center of scientific activity in England.[12]

In his earlier professional life Whewell seems to have been recognized as a scientist rather than as a man of dominantly philosophical interests. He introduced himself to the academic world with the publication of *An Elementary Treatise in Mechanics,* in

[11] Cf. IT, II, 20.

[12] Cf. T. J. Lawrence, *Dictionary of Political Economy,* article on *Whewell.*

1819. This text was the first innovation introduced into the Cambridge system of mathematics in many years.[13] It was used as a standard text there for some time, going through seven editions, in each of which it was extensively revised. Whewell supplemented it with *The Mechanics of Engineering,* published in 1841. He was also the author of several treatises on dynamics. Through these texts, and through his activities in connection with setting examinations in different years, Whewell exercised considerable influence on the development of mathematics and physics at Cambridge during several decades.[14]

Very likely the success of Whewell's books on mechanics inspired the invitation to him to write one of the *Bridgewater Treatises.* These were designed to be contributions "On the Power, Wisdom and Goodness of God, as manifested in the Creation."[15] As Whewell remarked in the preface to the first edition of his *Indications of the Creator,* published some years later, people are always ready to read about natural theology; consequently his *Bridgewater Treatise* introduced him to a wide circle of readers who would not be interested in his more strictly professional writings. Whewell was assigned the subject, *Astronomy and General physics considered with reference to Natural Theology.* He undertook to show how laws of physics and of astronomy are adapted to promote the welfare of the sentient creatures of the universe, and he concluded from this that the perfection of arrangement could be due only to the benevolence of the Creating Deity. Whewell's persuasive organization and vigorous presentation of the evidence earned the general approval which the work was accorded.

Whewell's personal interest in his subject lay chiefly in his discussion of inductive and deductive habits of mind.[16] The arrangement of the book did not serve to emphasize these considerations, and few readers shared Whewell's appreciation of the distinctions which he pointed out.[17] Whewell attempted to

[13] Cf. *Autobiography of Sir George Airy,* p. 26.

[14] For a more complete account of Whewell's contributions in this field, see Todhunter, op. cit., Vol. I, chap. ii.

[15] Cf. *Quarterly Review,* 1833, Vol. 50, pp. 1–34; and *Edinburgh Review,* 1834, Vol. 58, pp. 422–457.

[16] Cf. IT, II, 161. This discussion constituted the fifth and sixth chapters of the third book of the treatise.

[17] Cf. IT, I, 73; also reviews cited in note 15.

show that the existence of a Deity responsible for the design of the universe might conceivably be doubted by those who are engaged in making deductions from accepted first principles, but he denied that those who have discovered general laws by processes of induction could be similarly blind to evidences of creative purpose in the universe. Citing such men as Copernicus, Kepler, Galileo, Newton, Dalton, and Boyle as representative discoverers who had expressed convictions that the beauty and order of the universe must be regarded as evidence of the goodness and wisdom of its Creator, Whewell explained that the inductive search for truth in which these men had engaged is analogous to the finally successful effort of one individual to understand the conceptions of another, for the laws of the universe, Whewell suggested, are the ordinances of a responsible intelligence. The attempt to discover these laws through processes of induction forces upon the investigator the realization that the laws are not ultimate explanations. He still asks, "Why do we have just these laws and not others?" Deductive thinkers, on the contrary, are not inclined to look for explanations of the first principles from which they proceed. They accept these as given and concern themselves with deduction of the consequences. This difference in the attitudes of inductive and deductive thinkers explained in Whewell's eyes what he asserted to be the fact: that discoverers of new truths feel impelled to assume an intelligent and benevolent Creator, responsible for the order which they observe in the universe, while deductive thinkers frequently do not share in the recognition of this need for a final explanation.

The general contrast which Whewell pointed out between the processes of induction and of deduction was fundamental to his philosophy of discovery. Deduction, he maintained, cannot arrive at new truths, but can only make clear the consequences of accepted principles. The process of induction is contrasted with this "mere reasoning," and is described as a process through which the persistent effort to understand the connections of natural events is finally successful, and brings a sense of conviction and repose to the investigator. Whewell made no attempt to analyze the inductive process at the time that he wrote the *Astronomy and General Physics*. He merely repeated the familiar distinctions between induction and deduction, adding a statement of his conviction that deductive and inductive habits of mind might reasonably be found associated with different theological convictions.

In order to emphasize the evidences of design in the universe, Whewell pointed out the beautiful adjustment of organic rhythms to the succession of the seasons, and of night and day; he remarked the perfect adjustment of breathing to atmospheric pressure; and the fitness of the ear and eye to perceive the peculiar stimuli to which they respond. He dismissed the notion that a conception of progressive adaptation might be substituted for his own idea of original adjustment, arguing that a preliminary adjustment of some sort must be assumed in any case. This view of Whewell's indicates the conservative position which he maintained throughout his life.

On the other hand, Whewell supported this type of explanation by statements which do not seem harmonious with the theory of knowledge which he developed in the *Philosophy*. The idea that the physical universe has been purposely adjusted to satisfy the needs of the inhabiting organisms, implies that it might have been differently ordered. The laws of the universe are evidences of the goodness of God only because they are the best laws conceivable and must have been selected from all possible laws with benevolent intent. Whewell explicitly denied in his *Bridgewater Treatise* that even the most simple of these laws can be regarded as the only possible laws according to which the universe could be ordered.

"It would be easy to show that the fundamental laws of motion, in whatever form we state them, possess a very pre-eminent simplicity, compared with almost all others, which we might imagine as existing. This simplicity has indeed produced an effect on men's minds which, though delusive, appears to be very natural; several writers have treated these laws as self-evident, and necessarily flowing from the nature of our conceptions. We conceive that this is an erroneous view, and that these laws are known to us to be what they are, by experience only; that the laws of motion might, so far as we can discern, have been any others. They appear therefore to be selected for their fitness to answer their purposes; and we may, perhaps, be able to point out some instances in which this fitness is apparent to us." (BT, Book II, xi.)

It may have been statements like this which Herschel had in mind when he suggested that Whewell's views changed between the time of his writing the *Astronomy and General Physics* and the production of the *History* and *Philosophy of the Inductive Sciences*. Todhunter disagreed with Herschel on this point, claim-

ing that Whewell's more incidental writings and his correspondence indicate that Whewell had formulated the views which he presented in the *Philosophy* at the time when he wrote the *Bridgewater Treatise*. (IT, I, 70.) Todhunter objected to the selection from Whewell's writings of certain apparently inconsistent passages, rightly maintaining that these may misrepresent his general point of view. However, the above quotation represents an explicit assertion of a point of view which Whewell seemed to contravert at a later time,[18] and indicates that in fact he did elaborate his theory of induction while he was preparing the *History of the Inductive Sciences.*

The Mechanical Euclid, which was published four years after the *Bridgewater Treatise,* clearly suggests Whewell's final point of view. This text was evidently designed to meet the need which arose out of the Grace of 1837, requiring a knowledge of elementary mechanics and hydrostatics on the part of all candidates for degrees at Cambridge.[19] Theoretical interest in *The Mechanical Euclid* arises out of the fact that it presents the sciences of mechanics and hydrostatics in the same way that geometry is usually presented. The elements of each science are set forth in the form of distinct propositions which are demonstrated by reference to the "fundamental notions" and definitions which Whewell enunciated as preliminary to his discussions. The significant point about all this is that Whewell regarded statics, hydrostatics, and dynamics as demonstrative sciences, resting, like geometry, on certain axioms and definitions. Perception of the cogency of the proofs depends, Whewell maintained, upon the clear apprehension of the fundamental ideas which are involved in each science. The axioms which are referred to in the proofs are explicit expressions of truths which are considered by Whewell to be at once apparent to anyone who clearly apprehends the fundamental ideas.

"The Axioms of Statics in the preceding pages are simply stated, without addition or explanation; in the same manner in which the Axioms of Geometry are stated in Treatises on Geometry. As the Axioms of Geometry are derived from the idea of space, so the Axioms of Statics are derived from the idea of *statical force* or *pressure,* and the idea of *body* or *matter,* as that

[18] Cf. HSI, I, 240.

[19] In an appendix, Whewell included lists of previous examination questions, and he designated the particular propositions for which the student would be held responsible.

which receives and transmits pressure. The student must possess distinctly this idea of a force acting upon body, and body sustaining force;—of body resisting the action of force, and while it resists, transmitting this action;—of body with this mechanical property, existing in the various forms of rigid straight line, lever, plane, solid, flexible line, flexible surface;—and when he has this distinct possession of elementary ideas, the truth of the Axioms of Statics will be seen as self-evident, and he will be in a condition to go on with the reasonings by which the following Propositions are established." [20]

Such passages as this suggest that *The Mechanical Euclid* may be regarded as an application of Whewell's general principles in the exposition of particular sciences. The essence of Whewell's philosophy of science is expressed in the statement that thorough understanding of the ideas which are fundamental to any science is the necessary condition of perceiving the truth of the axioms and laws of that science. According to Whewell's view, it was particularly desirable to present the propositions of mechanics in the form which he chose because he could demonstrate by this mode of presentation that truths as evident and as well established as those of geometry are to be found in sciences which do not depend merely upon the development of ideas of space and number, but upon the development of more recently recognized ideas such as those of force and motion.[21]

Whewell did not emphasize the distinction that correct interpretations of the ideas fundamental to mechanics have been recognized only comparatively recently and are in process of further clarification. He regarded the Euclidean geometry and theories of number as not liable to future modification. Very possibly he believed that statics, hydrostatics and dynamics were about to assume the same impregnable position, as he regarded it, for he expressed a hope that the lists of propositions presented in *The Mechanical Euclid* might become classical just as the geometrical propositions of Euclid are.[22] There is not a little irony in the fact that "axioms" were included which were as little capable of enduring future criticism as the following:

[20] ME, Remarks on the Axioms of Statics, 5th edition, 1849, p. 32. Whewell's curious and erratic use of capitals is followed in quoting from him. The present writer has imitated him only to the extent of capitalizing "Fundamental Ideas" and other expressions which Whewell used in a peculiar sense.

[21] Cf. *Of a Liberal Education*, article 35.

[22] ME, Preface to the 4th edition.

"A heavy material straight line, prism, or cylinder, of uniform density, may be supposed to be composed of a row of heavy points of equal weight, uniformly distributed along the line." [23]

This failure to recognize the limitations of contemporary development in the sciences with which he was most conversant is at least partially excused by Whewell's belief that the progress in these sciences could only have occurred if the fundamental principles upon which they are based had been clearly apprehended. With such a philosophy, he could not suspect that newer discoveries might revolutionize the whole approach to sciences which he regarded as firmly grounded in indisputable first principles.

Whewell's philosophical views did not imply a neglect of the contribution of empirical findings to the development of science. On the contrary, Whewell emphasized the importance of observation and of experiment, and devoted a portion of his own time to labors of scientific investigation. In the summer of 1826, Whewell and Airy, then both Fellows of Trinity College, attempted to carry through an experiment suggested by Bacon in the *Novum Organum,* in order to determine the density of the earth. Accidents prevented success then and also in 1828 when they repeated the attempt. Airy finally succeeded in carrying through the plan in 1854. Although Whewell did not participate in the actual achievement, the earlier experiments in which he had engaged with Airy no doubt contributed to the eventual success of the project. Whewell's interest in the undertaking is evidence of his hearty respect for the painstaking investigation of details which must precede the discovery of general truths.

Further proof of Whewell's recognition of the need for empirical investigation as preliminary to scientific discovery is provided in his study of the tides. Whewell presented his contributions to "tidology" in a series of fourteen memoirs, published in the *Philosophical Transactions* between 1833 and 1850. The value of this work was recognized by the award of a medal to Whewell by the Royal Society in 1837.[24] Whewell was aware that he was working in a new field. Obviously the first step was to collect a wealth of data. Governmental support facilitated this project. Observations were ordered made at specified times at each of the

[23] ME, Book I, Axiom 13.

[24] Cf. Address of the President, *Philosophical Magazine,* Series III, Vol. XII, pp. 269 ff.; 351 ff.

coast guard stations in England, Scotland, and Ireland from June 7 to June 22, 1834. Similar observations were made simultaneously during the same period in the succeeding year on the coasts of Great Britain, North America, Spain, Portugal, France, Belgium, Holland, and Norway, through the cooperation of the respective governments. The observations were submitted to Whewell and clerks were provided to assist in tabulating the data. Whewell showed a masterly command of statistical methods in reducing the data to convenient form. The co-tidal maps which he drew were described by Airy as "the best specimens of the reduction of new observations that we have ever seen."[25] Whewell's endeavor was to ascertain first the facts about the tides, and he only occasionally ventured to suggest interpretations of his data. His whole approach to the study of "tidology" illustrates his views on the course of scientific progress, and in fact he asserted that these views had helped him in directing his endeavors fruitfully. (IT, II, 172.)

Although these efforts represented Whewell's most significant contributions to the discovery of facts for science, they do not indicate the wide range of interests which made him pre-eminently capable of undertaking the writing of a history and philosophy of all of the inductive sciences. In his contributions to the *Philosophical Transactions,* in his communications to the Cambridge Philosophical Society and the British Association for the Advancement of Science, in his reviews for the *Quarterly* and other periodicals, as well as in his pamphlets, notes, and scientific correspondence, Whewell showed his understanding appreciation of contemporary problems in the various sciences whose development he described in the *History.*[26] Whewell invented an anemometer which he exhibited at the Dublin meeting of the British Association in 1835. He communicated to M. Quetelet a paper on colored fringes which was published by M. Quetelet and which gave rise to some discussion at the Congress of Swiss Men of Science some years later.[27] *An Essay on Mineralogical Classification and*

[25] Airy, *Tides and Waves,* Art. 496. Quoted, IT, I, 85. Todhunter devoted chapter XII of this volume to a full discussion of Whewell's work on the tides.

[26] Todhunter lists these contributions in his first volume, usually adding some critical comments. A selected list of Whewell's published writings is appended to the present essay.

[27] Cf. *Philosophical Magazine,* April, 1851, pp. 336–337.

Nomenclature (1828) and a paper *On the Employment of Notation in Chemistry* (1831) represent Whewell's contributions to chemistry and mineralogy. These were regarded as more important in Whewell's own time than they seem in the light of more recent progress, but undoubtedly they assisted progress toward the adoption of simple and convenient forms of designation.[28]

When Lyell's *Principles of Geology* appeared, Whewell was asked to review the work.[29] He failed to appreciate the significance of Lyell's revolutionary theory of uniformitarianism, but that did not prevent the latter from nominating Whewell as his successor to the presidency of the Geological Society in 1837. Whewell appreciated recognition of this sort, for he seemed to suspect that some might resent his assumption of authority to criticize in all fields of science, and his election to the presidency of the Geological Society was a mark of esteem for his work in one field to which he never devoted any considerable proportion of his time. In 1845 he published his *Remarks on Glacier Theories,*[30] showing that his interest in geological problems persisted when he was devoting himself primarily to philosophy and to his executive duties as Master of Trinity.

Whewell carefully refrained from any discussions of the social sciences in the *History* and *Philosophy,* for he believed that they were not yet so firmly established as to warrant their inclusion in a survey of our most certain bodies of knowledge. (PD, 239.) However, his reputation for possessing almost universal information probably took account of his contributions in the fields of political economy and ethics. In 1829, he read a paper entitled *Mathematical Exposition of some Doctrines of Political Economy,*[31] which Sidgwick mentioned as "the earliest systematic application by an Englishman of mathematic symbols to political economy."[32] Whewell presented other memoirs on the same topic in 1831 and 1850. Eleven years after the last of these had appeared, Whewell distributed copies of six lectures in political

[28] Cf. L. J. Spencer, writing in the *Encyclopedia Britannica,* article on *Crystallography.*

[29] *British Critic,* January, 1831. No. 17, pp. 180–206.

[30] *Philosophical Magazine,* 1845. Vol. 26, pp. 171–173, 217–220, 334–342.

[31] *Cambridge Philosophical Transactions,* Vol. 3, pp. 191–230; Vol. 4, pp. 155–198; Vol. 9, part i, pp. 123–149; part ii, pp. 1–7.

[32] Henry Sidgwick writing in the *Dictionary of Political Economy,* article on *Political Economy: Method.*

economy which he had prepared by invitation for the benefit of the Prince of Wales. These contributed nothing essentially new, but the invitation testifies to Whewell's eminence in the field of political theory.

Whewell's work in morals engaged a major part of his time in the later years of his life, after he had accomplished his greatest contribution to science with the writing of the *History* and the *Philosophy of the Inductive Sciences.* His contributions to the moral sciences, as he called ethics, were not especially significant. His nativistic theory of a supreme "moral faculty" could not appeal to a public which had been taught by Locke to reject all innate ideas, and which was enthusiastic about the associationist approach to all problems that could be interpreted from a psychological point of view. Whewell's ethics presented another aspect of the apriorism which many criticized in his philosophy of science. Although Whewell considered that the Cambridge Platonists defended a point of view which was being definitely superseded as early as the close of the seventeenth century, and although he remarked the need of a new moral theory "where experience gives reality to Ideas, and Ideas give universality to the truths which we gather from experience," [33] the theory which Whewell proposed appears to belong rather to the age of Cudworth and Clarke than to that of Herbert Spencer.

Among Whewell's more significant contributions to moral philosophy may be counted his translations of the Platonic Dialogues.[34] These were published in three volumes which appeared in 1859, 1860, and 1861, respectively. They were designed to meet what Whewell regarded as the need for modern English translations of the works of the ancient Greeks, with critical comments indicating the most recent interpretations of Greek views.[35] Whewell had been appointed to the "Professorship of Moral Theology and Casuistical Divinity" at Cambridge in 1838, and in his lectures on moral philosophy, as he preferred to term his subject, he of course had occasion to refer to Plato and to work up some of the material which he introduced into his *Platonic Dia-*

[33] *Lectures on the History of Moral Philosophy in England,* p. 68.

[34] Cf. IT, I, 277 ff. Whewell made rather free translations from the original, frequently giving up the dialogue form and adding explanatory comment.

[35] Cf. *On a Liberal Education,* articles 93 and 326.

logues for English Readers. Perhaps as an incidental issue, Plato's epistemological theory was carefully considered by Whewell. A comparison of the third chapter of the *Philosophy of Discovery* and of the first four appended essays with the earlier written discussion presented in chapter two of the same volume, reveals the fact that Whewell's conception of Plato's contribution to the theory of knowledge became much more appreciative as he reviewed Plato's work more thoroughly. In the first two editions of the *Philosophy of Induction,* Whewell decried Plato's neglect of facts with the same emphasis with which he approved Plato's recognition of ideas as necessary elements of knowledge. When the third edition appeared in 1857, the appended essays and the additional chapter gave an account which is so much more enthusiastic that it is scarcely surprising to find a critic referring to Whewell's "ultra-Platonic hypothesis."[36]

The numerous contributions which Whewell made to particular sciences, and his efforts in behalf of various educational and administrative reforms at Cambridge, represent additional achievement aside from Whewell's main work. Although his *Plurality of Worlds,* published anonymously in 1853, was widely read and discussed because of his attack on the current assumption that the earth is only one of a number of inhabited planets, it does not represent a serious contribution to science. It may be discussed, along with Whewell's poetical efforts, his translations from German prose and poetry, his essay on architecture, and his sermons, as the casual contribution of a man whose boundless energy won him time for the accumulation of an unexcelled wealth of information and for the effective presentation of his many original ideas. Whewell's essential life work, and that which constitutes his main claim to fame, is his *History of the Inductive Sciences, from the earliest to the present time,* and his *Philosophy of the Inductive Sciences, founded upon their History.*

Whewell spoke of the *History* and *Philosophy* as primarily a "description of the processes by which Scientific Truth is discovered and established." (HSI, II, 324.) He regarded his study of the historical development of the separate sciences as preparatory to the development of a theory of discovery just as

[36] W. G. Clark, *William Whewell, In Memoriam. MacMillan's Magazine,* April, 1866. Vol. 13, p. 547. Reprinted in *Littell's Living Age,* Vol. 89, pp. 355–360.

the physical scientist regards the collection of data as preliminary to the formation of hypotheses. "We purpose to collect our doctrines concerning the nature of knowledge, and the best mode of acquiring it, from a contemplation of the Structure and History of those Sciences (the Material Sciences), which are universally recognized as the clearest and surest examples of knowledge and of discovery,"—so Whewell announced the empirical fashion in which he would attack his problem. (HSI, I, 8.) Although it may be suspected that Whewell was aided in the organization of his material by an early conviction that there is an *a priori,* ideal element in all scientific theories, and that the great step in progress consists in the recognition of this ideal element, it cannot be denied that Whewell used expressions in his earlier writings [37] which suggest that his convictions did become more clear and more definitely established during the preparation of the *History.* This preliminary work was accomplished in 1837. Three years later it was followed by the *Philosophy of the Inductive Sciences, founded upon their History,* the first parts of which had been written along with the *History.* When second and third editions were called for, the *Philosophy* was broken up into the *History of Scientific Ideas,* the *Philosophy of Discovery,* and the *Novum Organon Renovatum.*

In the *History of Scientific Ideas,* Whewell reviewed again the history of the inductive sciences, selecting for emphasis the new ideas and conceptions which had been introduced in every forward step in science, according to his analysis. The new *Philosophy of Discovery* presents a "Review of Opinions on the nature of Knowledge and the Method of seeking it," [38] with additional chapters which made the account more complete than it had appeared in previous editions of the *Philosophy,* and with answers to some contemporary critics. Eleven essays on relevant topics, which had previously appeared elsewhere, were appended to the volume. The *Novum Organon Renovatum* presents Whewell's conception of the methods of discovery and of the logic of induction in the form of aphorisms and discursive chapters. Extensive remarks on the language of Science make up the fourth book of the *Novum Organon Renovatum.*

Whewell conceived his work to be in many respects a revival of

[37] Cf. Remarks on the *Bridgewater Treatise* above, p. 8.

[38] PD, preface, p. vi.

Bacon's project. The *History of the Inductive Sciences* corresponds to Bacon's *Advancement of Learning* in being a preliminary survey of the development of the sciences up to the writer's time. (IT, II, 233.) Whewell's crowning volume is entitled *Novum Organon Renovatum* with direct reference to Bacon's work. As Bacon's *Novum Organum* represented an effort to supplement Aristotle's *Organon* by providing methods for augmenting man's treasure of real knowledge, so Whewell's *Novum Organon Renovatum* was designed as an improvement upon Bacon's work in the light of the actual progress that had been made in the sciences since Bacon wrote. (NOR, preface.) Whewell was not so much concerned to discover practical precepts as his great predecessor had been. Bacon desired to increase human power and knowledge by providing a method which would insure the most effective employment of the human faculties; Whewell's purpose was to learn from a history of science how, in fact, men have arrived at the certain and stable truths whose discovery has marked the progress of thought, and also what this implies concerning the nature of knowledge. This epistemological trend of Whewell's discussion is to be accounted for not only by the philosophical progress of the intervening two and a half centuries, but also by Whewell's interest in the purely theoretical aspects of the problems of induction. Whewell believed that his method of approach contrasted with Bacon's in aiming to discover inductively what factors have actually contributed to scientific progress and to conclude from this what are the essential steps in scientific discovery. The actual progress made in the sciences since Bacon had proposed his scheme for the empirical study of nature provided a means for determining where that "Hero of the revolution in scientific method" had divined correctly the methods of scientific advance and where his speculations had been mistaken. (PD, 128.) Whewell was consistently enthusiastic about Bacon's contributions, although he believed that Bacon had been wrong in some major points. He even expressed the opinion that modern critics should emphasize those aspects of Bacon's theory which time had proved to be correct, and should neglect consideration of those false notions which Bacon mingled with the true.[39]

[39] *Edinburgh Review,* October, 1857. Vol. 106, pp. 302 ff.

Whewell was convinced that Bacon had expressed ideas which were more correct than those propounded by a generally admired contemporary of Whewell's.[40] Comte's *Cours de Philosophie Positive* had been reviewed by Sir David Brewster in the *Edinburgh Review*[41] a few months after the same writer's review of Whewell's *History* had appeared.[42] Brewster contrasted Comte's arguments on several points with what he regarded as Whewell's inferior treatment of the same subjects. John Stuart Mill's enthusiasm for Comte also contributed to the Frenchman's reputation, for Mill's views soon became the dominating philosophy at Cambridge as elsewhere in England. Whewell referred to Mill as " quite subjugated by one whom I think a very bad philosopher, Comte, of whom he constantly talks with a veneration which I could easily shew you is a most gross idolatry." (IT, II, 314.) Whewell believed that Comte's Law of the Three Stages was an illicit generalization, " contrary to history in fact, and contrary to sound philosophy in principle." (PD, 233.) Whewell scarcely recognized his points of agreement with Comte, as, for instance, their common appreciation of the differences in methods employed in the different sciences, and their common belief in the necessary priority of certain sciences, which seem to be fundamental, to others.

The contrast which Whewell drew between Bacon and Comte indicates that he regarded the latter as one who failed to use the material which the history of science presented. Although others might complain that Whewell failed to profit by the Frenchman's earlier publication,[43] it is plain that Whewell himself regarded his investigation of the history of the development of the sciences as a very different sort of undertaking from Comte's treatment of this development. Whewell was not so much concerned to elaborate a philosophical point of view as to solve the epistemological problem which he set himself when he attempted to learn from history what is involved in the discovery of fundamental laws of science. Whewell treated the *History* as preliminary to a *Philos-*

[40] *Ibid.*, p. 310.

[41] *Edinburgh Review*, July, 1838. Vol. 67, No. 136, pp. 271–308.

[42] *Edinburgh Review*, October, 1837 to January, 1838. Vol. 66, No. 133, pp. 110–151.

[43] Sir D. Brewster, *Edinburgh Review*, July, 1838. Vol. 67, No. 136, p. 274.

ophy of the Inductive Sciences, but even in the latter work he confined himself to an analysis of knowledge and a description of the process of discovery. Whewell never attempted to complete a system of philosophy except in so far as that was necessitated by the queries which grew out of his proposed solutions of epistemological problems.

The apriorism which Whewell regarded as a necessary conclusion from his analysis of knowledge as revealed in the development of the physical sciences, was not congenial to his fellow-countrymen. Whewell's course of thought diverged too far from the contemporary philosophical tendencies in England to win a favorable hearing. Leslie Stephen probably expressed the general opinion when he described Whewell's views as "radically incoherent," adding that "he made no converts." [44] This general rejection of his philosophical point of view caused Whewell to be almost forgotten when his dominant personality could no longer emphasize the significance of his thought. In the last half century, there has seemed to be singularly little appreciation of the actual contributions which he made to the philosophy of science. The following exposition of his views may reveal their fruitful suggestiveness and also show how the too apparent difficulties which he encountered in the development of his theory discredited it in the eyes of contemporary thinkers.

[44] L. Stephen, *The English Utilitarians,* Vol. III, p. 143.

CHAPTER II.

The Fundamental Antithesis.

Whewell's *Philosophy of the Inductive Sciences* opens with a chapter in which Whewell described the purpose of his undertaking. He hoped to make some preliminary contributions to a philosophy of science by winning an insight into the conditions of real knowledge and the best methods for discovering new truths. He explained how the material for the *Philosophy* had been gathered from an historical survey of all of the sciences which were generally acknowledged to be made up of bodies of certain and stable truths. After this introductory announcement, he proceeded directly to lay down the fundamental principles underlying his philosophy.

Whewell believed that there are two elements in knowledge which are inseparable in actual experience but which must be distinguished in philosophical speculation. All experience, he insisted, involves both *ideas* and *sensations.* Although men are not commonly aware of the ideal element in what they term sensory experience, it is always present, just as sensory data are always implied in our more abstract thinking. These two elements of experience, the subjective, ideal element, and the objective, sensory content, are always found together in experience as the necessary complements of each other. Yet in philosophical thought these two elements must be contrasted as antithetical. Whewell referred to what he considered this essential philosophical distinction as the " Fundamental Antithesis of Philosophy."

The fundamental antithesis is represented in other contrasts besides the distinction between ideas and sensations. In Chapter One of the first book of the *History of Scientific Ideas,* Whewell considered various ways in which the antithesis is exemplified. He discussed in turn the distinctions between thoughts and things, between necessary and experiential truths, between deduction and induction, between theories and facts, between ideas and sensations, between the subjective and the objective, and between matter and form. In each case, Whewell pointed out that the

contrasted items are invariably and necessarily found together in experience, although from a philosophical point of view they must be regarded as antithetical.

"All these forms of antithesis, and the familiar references to them which men make in all discussions, show the fundamental and necessary character of the antithesis. We can have no knowledge without the union, no philosophy without the separation, of the two elements." (PD, 465.)

The opposition of thoughts and things, Whewell described as "the simplest and most idiomatic expression of the antithesis." (HSI, I, 24.) This distinction is not confined to philosophical thinking, but is commonly recognized in everyday speech. People ordinarily refer to things as existing externally and independently of their relations to any percipient organism. Thoughts, on the other hand, are regarded as having only a mental existence, and as essentially dependent on the activity of some thinker. Whewell pointed out that, actually, things and thoughts can enter experience only in conjunction with each other. Our experience of things always involves some thinking about them. We attribute to them locations in space, and degrees of size, of weight, *et cetera.* These characters which we habitually assign to things belong in fact to our thoughts about things, for the spatial relationships, and the determinations of extension and of mass which are involved in these judgments are contributed to experience by thoughts, according to Whewell, who followed Kant in maintaining that primary qualities are dependent upon *a priori* conditions of understanding. Thus the Fundamental Antithesis seems to be well represented in the contrast between thoughts and things, for these cannot be separated in actual experience, although they are commonly distinguished in our analyses of experience.

Whewell seemed to regard things as independent reals in the same sense that the naïve realist does, but he assumed the critical standpoint that things can be known only as transformed by our thinking about them. (HSI, I, 25.) Things exist independently of any perceiver, but they can be apprehended only under the forms of thought. Man is never purely passive in experience, for experience always involves some activity, some contribution of ideas. In discussing the antithesis of thoughts and things, Whewell seemed to take the position of a critical philosopher who still insisted on the reality of the things-in-themselves. He denied

that these things can be known except as transformed by thoughts, and at the same time he maintained that things must be real if there is to be any reality to be known. He avoided the idealism of the post-Kantians by asserting a dogmatic faith in the reality of an independent universe which, he admitted, can be experienced only as thought, that is, as combined with mental elements.

This epistemological dualism of thoughts and things as the indispensable but antithetical elements of knowledge is a fundamental principle underlying Whewell's philosophy. Although he claimed that "one single act of mind involves them both; and their contrast disappears in their union," he regarded the analysis of experience into these antithetical abstractions as a necessary preliminary to the development of any satisfactory theory of knowledge. (HSI, I, 25.)

Whewell next illustrated the Fundamental Antithesis by reference to the distinction between necessary and experiential truths. Following the custom of logicians, Whewell spoke of this distinction as if it were perfectly simple and clear. Necessary truths, he implied, are those which can be seen to be true by an examination of our own thoughts, independently of experience; experiential or contingent truths, on the other hand, are discovered through experience and apparently might have been different from what they are actually found to be. A recognition of this difference between necessary truths and contingent truths is essential to understanding any analysis of knowledge, Whewell asserted.

"The separation of truths which are learnt by observation, and truths which can be seen to be true by a pure act of thought, is one of the first and most essential steps in our examination of the nature of truth, and the mode of its discovery. If anyone does not clearly comprehend this distinction of necessary and contingent truths, he will not be able to go along with us in our researches into the foundations of human knowledge; nor, indeed, to pursue with success any speculation on the subject. But, in fact, this distinction is one that can hardly fail to be at once understood. It is insisted upon by almost all the best modern, as well as ancient, metaphysicians, as of primary importance. And if any person does not fully apprehend, at first, the different kinds of truth thus pointed out, let him study, to some extent, those sciences which have necessary truth for their subject, as geometry, or the properties of numbers, so as to obtain a familiar acquaintance with such truth; and he will then hardly fail to see how dif-

ferent the evidence of the propositions which occur in these sciences, is from the evidence of the facts which are merely learnt from experience." (HSI, I, 60.)

Whewell illustrated contingent truths by reference to the discoveries that the stars revolve around the pole in one day, while the moon goes through her phases in thirty days; that sugar dissolves in water to form a colorless liquid; and that plants cannot live without light. Necessary truths, on the other hand, are exemplified in geometrical propositions, and in numerical relationships. We perceive that twenty-seven and thirty-eight must be equal to sixty-five, and that the three angles of a triangle must be equal to two right angles. These are truths which experience could not conceivably contradict. (PD, 462 ff.) Such necessary truths are derived from our own thoughts, while contingent truths are learned through experience with things. Thus the distinction between them is related to the distinction between thoughts and things by which the Fundamental Antithesis was first illustrated.

"It is evident that this distinction of Necessary and Experiential Truths involves the same antithesis which we have already considered;—the antithesis of Thoughts and Things. Necessary Truths are derived from our own Thoughts. Experiential Truths are derived from our observation of Things about us. The opposition of Necessary and Experiential Truths is another aspect of the Fundamental Antithesis of Philosophy." (HSI, I, 27.)

In the passages which have been quoted, Whewell spoke as if the distinction between necessary and contingent truths must be regarded as absolute and as based upon an equally clear distinction between thoughts and things. It will be remembered, however, that he insisted that thoughts and things are never separated in actual experience. This suggests that necessary and contingent truths also may not be so clearly distinguishable as Whewell sometimes implied. Both are discovered in the course of experience, and since experience always involves both thoughts and things, necessary truths cannot depend wholly upon thoughts, nor contingent truths wholly upon things. The distinction would appear to be relative: although both thoughts and things are always involved in the apprehension of any truth, they are mixed in unequal proportion. Where truths seem to be evident from mere consideration of our thoughts, abstracted from concrete data

from experience, those truths are regarded as necessary in the same sense that logical principles are regarded as necessary. Where, on the other hand, experience of real events is obviously an indispensable condition of the recognition of truths, those truths are regarded as contingent. That the distinction can never be absolute is clearly implied in Whewell's frequent assertions to the effect that "the terms which denote the fundamental antithesis of philosophy cannot be applied absolutely and exclusively in any case." (PD, 466.)

Whewell did speak, however, as if certain principles must be designated as absolutely necessary, while empirically discovered laws must be considered as merely general. Referring to the examples of contingent truths which he had just cited, Whewell commented:

"We have here propositions *rigorously* true, (we will assume,) but can anyone say they are *necessarily* true? These, and the great mass of the doctrines established by induction, are actual, but so far as we can see, accidental laws; results determined by some unknown selection, not demonstrable consequences of the essence of things, inevitable and perceived to be inevitable." (HSI, I, 60.)

According to Whewell, the sciences are bodies of general truths, some of which are merely empirical laws, while others are necessary principles. Whewell never explicitly asserted that the inductive sciences boast truths as simple and necessary as those of geometry, but he claimed that some inductively established truths do at least *approach* to the simplicity and universality of necessary principles, and come to seem as necessary and indubitable as the axioms of geometry. Whewell refused to commit himself to an assertion that the doctrine of universal gravitation, the laws of motion, the laws of the phenomena of light, and the general principles of chemistry are necessary. He restricted himself to this cautious statement:

"If these doctrines *are* universally true, this universality flows from the *ideas* which we apply to our experience, and which are, as we have seen, the real sources of necessary truth. How far these ideas can communicate their universality and necessity to the results of experience, it will hereafter be our business to consider. It will then appear, that when the mind collects from observation truths of a wide and comprehensive kind, which approach to the simplicity and universality of the truths of pure

science; she gives them this character by throwing upon them the light of her own Fundamental Ideas." (HSI, I, 67.)

Just where Whewell attempted to settle the question of how far the mind can contribute universality and necessity to the laws of the natural sciences, is not clear. As Todhunter has remarked, Whewell had an unfortunate habit of referring to matters treated "elsewhere" without giving any precise indication of his reference. (IT, I, 105.) In this instance it seems safe to state that Whewell never did specifically discuss the problem which he suggested in this passage.

Whewell believed that a distinction between necessary and contingent truths is fundamental to an analysis of knowledge, but he was also convinced that truths discovered in the course of experience may eventually approach the certainty and simplicity of necessary truths, until they are distinguished from the latter only by their necessary derivation from experience and by the fact that a contrary conception does not appear to most people to be essentially irrational. Just as experience involves the two elements of thoughts and things, so science involves necessary and contingent truths; moreover, just as thoughts and things cannot be separated in experience, although they are commonly distinguished in our discussions, so there cannot be any perfectly valid distinction between the empirical and the necessary elements of science, despite the fact that the distinction between necessary and contingent truths is one which has been familiar since it was proposed among the ancient Greeks.

Another aspect of the Fundamental Antithesis is represented by the contrast between induction and deduction. According to Whewell, induction is a means of discovering new truths by finding an Idea which agrees with the facts, while deduction involves the demonstration of particular truths by reference to recognized first principles. Whewell was particularly concerned to emphasize the distinction that inductive processes provide means of arriving at new generalizations, of discovering truths which are essentially new, while deductive processes are fruitful only in making possible the verification and application of general truths. However, Whewell did not mean to disparage deduction in contrast to induction, but rather wished to point out that induction, although lacking the demonstrative certainty which attaches to deduction, is an equally important way of getting at the truth.

He emphasized the fact that induction and deduction necessarily supplement each other. Through inductive processes, men have advanced from particular facts to general truths; deductive processes are employed in the verification and application of these truths. Whewell related this distinction to the antithesis which he had pointed out between thoughts and things and between necessary and experiential truths. He remarked that deduction arrives at necessary truths by considering relations between our own thoughts, while induction yields experiential truths grounded in observation of things.

"Deductive truths are the results of relations among our own Thoughts. Inductive truths are relations which we discern among existing Things; and thus, the opposition of Deduction and Induction is again an aspect of the Fundamental Antithesis already spoken of." (HSI, I, 29.)

Whewell next considered the Fundamental Antithesis as represented in the contrast of theories and facts. In discussing this aspect of the Antithesis, he made more evident the point upon which he insisted in his earliest remarks. The Antithesis involves a contrast which cannot be maintained in actuality, for the antithetical elements are necessary complements of one another in experience; yet in philosophy the distinction is essential. Whewell frequently asserted his conviction that recognition of the Antithesis is a necessity of analytical thinking although the terms cannot be accurately and exclusively applied to particular cases. (PD, 465.)

The distinction between facts and theories seems at first to be as clear as the distinction between thoughts and things.

"A Theory is an Inductive Proposition, and the Facts are the particular observations from which, as I have said, such Propositions are inferred by Induction. The Antithesis of Theory and Fact implies the fundamental Antithesis of Thoughts and Things; for a Theory (that is, a true Theory) may be described as a Thought which is contemplated distinct from Things and seen to agree with them; while a Fact is a combination of our Thoughts with Things in so complete agreement that we do not regard them as separate." (HSI, I, 29.)

Even in this paragraph, however, Whewell indicated that the distinction between facts and theories has a decidedly subjective basis. Facts as well as theories involve reference to both thoughts and things, but in "theories" the thoughts are contemplated

separately from the things, while in "facts" they are not regarded as separable. The distinction depends, then, upon the point of view and the attitude of the observer. If he regards a certain item of experience as a theory, it is because he analyzes the item into sensory data and explanation, and attends chiefly to the latter; if he regards the item as a fact, it is because he fails to attend to the theories implied in his apprehension of it as a fact. The course of history shows how this change tends to occur as theories become more familiar. The theoretical element comes to be so familiarly accepted that it is no longer regarded as an attempted explanation of certain facts; it is looked upon as a part of the facts. The designations "fact" and "theory" are applied to the same matters at various times in history, according to the different points of view of those who are considering them. "Is it a Fact or a Theory that the planet Mars revolves in an Ellipse about the Sun?" Whewell asked. And he answered his own question: "To Kepler, employed in endeavoring to combine the separate observations by the Conception of an Ellipse, it is a Theory; to Newton, engaged in inferring the law of force from a knowledge of the elliptical motion, it is a Fact." (NOR, 116.) When Whewell summed up the essential points in his discussion of the distinctions between facts and theories, he made it very clear that the distinction is merely subjective and relative, not objective nor absolute.

"The distinction between Theory (that is, true Theory) and Fact, is this: that in Theory the Ideas are considered as distinct from the Facts: in Facts, though Ideas may be involved, they are not, in our apprehension, separated from the sensations. In a Fact, the Ideas are applied so readily and familiarly, and incorporated with the sensations so entirely, that we do not see *them*, we see *through them*. . . And thus, a true Theory is a Fact; a Fact is a familiar Theory. That which is a Fact under one aspect, is a Theory under another. The most recondite Theories when firmly established are Facts: the simplest Facts involve something of the nature of Theory." (HSI, I, 44.)

Whewell has deserved credit for much originality in appreciating the relativity of the distinction between facts and theories, especially because he was writing at a time when it was the fashion to present very clear-cut definitions and to reduce, or try to reduce, all experience to sensational elements. Whewell showed that any scientific "fact" is actually so pregnant with implicit theory that

it is regarded as a fact only because the theoretical element is very familiar and can be taken for granted. He denied the finality of the designation in these emphatic words:

"Thus we are often told that such a thing is *a Fact;* A FACT and not a Theory, with all the emphasis which, in speaking or writing, tone or italics or capitals can give. We see from what has been said, that when this is urged, before we can estimate the truth, or the value of the assertion, we must ask to whom is it a Fact? what habits of thought, what previous information, what Ideas does it imply, to conceive the Fact as a Fact? Does not the apprehension of the Fact imply assumptions which may with equal justice be called Theory, and which are perhaps false Theory? in which case, the Fact is no Fact. Did not the ancients assert it as a Fact, that the earth stood still, and the stars moved? and can any Fact have stronger apparent evidence to justify persons in asserting it emphatically than this had?" (HSI, I, 48.)

In all of these illustrations, it is apparent that Whewell had in mind the primary distinction between ideas and sensations. In the chapter entitled "Of the Fundamental Antithesis of Philosophy," he spoke of this distinction merely as one of the aspects of the Fundamental Antithesis (HSI, I, 23 ff.), but in the *Novum Organon Renovatum,* he singled out this aspect of the Antithesis for special attention.

"*The antithesis of* Sense *and* Ideas *is the foundation of the Philosophy of Science. No knowledge can exist without the union, no philosophy without the separation of these two elements.*" (NOR, 5.)

Whewell's interpretation of the progress of science, and his theories about the nature of induction were made in terms of sensations and ideas treated as disparate elements of knowledge. Sensations contribute the content of experience; ideas give it form. Whewell endeavored to make his meaning clear by analogy with the antithesis of matter and form, with which philosophical thinkers had been familiar since the time of Aristotle.

"Sensations and Ideas in our knowledge are like Matter and Form in bodies. Matter cannot exist without Form, nor Form without Matter: yet the two are altogether distinct and opposite. There is no possibility either of separating, or of confounding them. The same is the case with Sensations and Ideas." (NOR, 6.)

As matter and form are distinguishable aspects of bodies, so matter and form are aspects of knowledge which can be considered in abstraction from one another, although they are never separated in reality. Sensation contributes the matter of knowledge; ideas contribute the form. Just as matter cannot exist without form, so sensation cannot exist without ideas, for ideas give to the crude data of sensation the form under which it is apprehended. Whewell emphasized the point that sensation cannot be regarded as existing prior to ideas by criticizing the expression, "ideas are *trans*formed sensations." He substituted the phrase, "ideas are *in*formed sensations," meaning that ideas are the necessary forms of understanding under which sense data are apprehended. (HSI, I, 41.)

In spite of the fact that Whewell insisted upon the absolute contrast between ideas and sensations, he was concerned to show that neither ideas nor sensations are ever experienced independently of one another. In defiance of the Lockian tradition, Whewell pointed out that the mind can never be purely passive in sensation. In any perception, there is involved some activity of the mind. Sensory data are immediately interpreted under the forms of space and time, and in terms of the categories of the understanding, as Kant had shown. Whewell referred to the Kantian forms and categories as "ideas," but obviously he followed Kant closely in contending that there is no sensation without an act of the mind, and that the activity of the mind is represented in experience by ideas which give form to the raw material flowing in through the sensory channels and so make possible its intelligible interpretation. (HSI, I, 40.)

Whewell explicitly criticized the doctrine of the Associationists and of all of those who spoke of sensations as the primary elements from which all conscious experience is derived. From Whewell's point of view, pure sensation, such as we talk of in theory, is a logical ultimate, but is never found in experience. Experience always presents us with a fusion of ideas and sensations. The empiricists had insisted that there are no ideas without sensations; Whewell maintained that there are no sensations without ideas. According to him, the two elements are mutually essential components of any experience. He criticized the doctrine that ideas are necessarily subsequent to sensory experience and therefore dependent upon sensation, claiming that neither

element is really prior to the other. When we talk of either alone we are discussing abstractions which are never presented independently of one another in experience. Questions of priority and dependence are meaningless because the two elements necessarily appear together. Neither can be shown to be either logically or psychologically prior to the other. Whewell expressed this view in his paper *On the Fundamental Antithesis of Philosophy,* which he read to the Cambridge Philosophical Society after critical reviews of the *History* and *Philosophy* had indicated that these notions of Whewell's were by no means acceptable to the majority of his contemporaries. (PD, 462 ff.)

"I remark further, that since in every act of knowledge, observation or perception, both the elements of the fundamental antithesis are involved, and involved in a manner inseparable even in our conceptions, it must always be possible to derive one of these elements from the other, if we are satisfied to accept, as proof of such derivation, that one always co-exists with and implies the other. Thus an opponent may say, that our ideas of space, time, and number, are derived from our sensations or perceptions, because we never were in a condition in which we had the ideas of space and time, and had not sensations or perceptions. But then, we may reply to this, that we no sooner perceive objects than we perceive them as existing in space and time, and therefore the ideas of space and time are not derived from the perceptions." (PD, 470.)

It is clear that Whewell did not mean to insist upon the existence of innate ideas in the sense in which Locke had criticized that belief. Locke used "idea" "to stand for whatsoever is the *object* of the understanding when a man thinks."[1] Whewell defined "ideas" as "that element, supplied by the mind itself, which must be combined with Sensation in order to produce knowledge." (HSI, I, 34.) Whewell used the term "Fundamental Idea" as synonymous with Kant's forms and categories, neglecting Kant's distinction between these last. He took the Kantian point of view that these Fundamental Ideas, to use Whewell's term, "are necessary conditions of knowledge, universal forms of intuition, inherent types of mental development;" adding, "They may even be termed, if anyone chooses, results of connate intellectual tendencies." (PD, 530.)

When Whewell defined ideas in terms like this, he seemed to

[1] *Essay concerning Human Understanding,* Introduction, Section 8.

be making a perfectly definite distinction between ideas as the formal elements of knowledge and sensations as content. When he spoke of particular Fundamental Ideas, as for instance, the *Idea of Space,* the *Idea of Number,* the *Idea of Force,* he sometimes seemed to imply that these could be considered in their purity, apart from the sensational content which is associated with them in experience. (NOR, 164 ff.) This manner of speaking, however, Whewell regarded as merely a necessary simplification in order to explain clearly his conception of knowledge. Actually, he insisted, sensations and ideas are always found together in experience. It is only by a process of abstraction that we can consider the terms in separation from one another.

In this contention that pure sensations and pure ideas are merely logical ultimates never found in experience, Whewell seemed to have some appreciation of the point that Maimon urged against the Kantian view of the *ding-an-sich,*[2] although it is not probable that Whewell was acquainted with Maimon's criticism and it is certain that Whewell did not follow through the implications of his view as Maimon did. Maimon pointed out the fact that the concept of the *ding-an-sich* is essentially irrational. The critical standpoint had made it clear that man can have no consciousness of things except as they appear under the forms of perception and the categories of the understanding. But *dinge-an-sich* are by definition independent of the forms and categories, and are regarded only as the unknowable sources of the "given" in our knowledge. Maimon called attention to the fact that this conception of unknowable *dinge-an-sich* is clearly irrational, since it implies a concept of something expressly defined as inconceivable. Maimon recognized, however, that the "given" content of knowledge must be explained in some fashion. He proposed the view that "the given" is that element of knowledge of which the thinker is not the conscious cause, and which he never wholly comprehends. The so-called "given," Maimon suggested, must be regarded as the limit which is continuously approached but which can never be attained in the persistent striving toward complete

[2] Among Whewell's papers now in the files of Trinity College Library, Cambridge, there are said to be copious notes on the *Kritik der Reinen Vernunft.* An examination of these papers would probably throw considerable light on Whewell's conception of his relation to Kant, and on his points of agreement with post-Kantian critics.

and perfect knowledge.[3] Whewell's recognition of the fact that we can never get back to "pure sensations" and "pure ideas" logically leads to Maimon's conclusion when combined with Whewell's view that the growth of science represents progressive "idealization of facts." (PD, 301.) But Whewell never questioned the existence of things which, in common sense fashion, he assumed as the origins of the sensational elements in experience.

It is evident that Whewell's predilection for a naïvely realistic point of view, and his preliminary definition of science as "the right interpretation of Nature" (NOR, 5), prevented his pursuing his notion of the Fundamental Antithesis with the subtlety of the German post-Kantians. With them, Whewell recognized that thoughts and things are essentially and inextricably mingled in experience, but it did not occur to Whewell to criticize the validity of distinctions which, by his own explicit and emphatic statement, can never be discovered in experience. Pure sensations and pure ideas, Whewell argued, are never found in experience, but the concepts "pure sensations" and "pure ideas" are nevertheless necessary terms in epistemological analysis. The criticism which Maimon urged against Kant is directly applicable to these views of Whewell's, but Whewell wrote as if all unconscious of the post-Kantian criticism except as represented in the philosophical systems of Fichte, Schelling and Hegel.

Whewell did not regard himself as a follower of any previous thinker, for he insisted that his analysis of knowledge had been developed inductively and was based only on a painstaking study of the actual, historical course of scientific progress. Whewell recognized a debt to Kant, but he was also very conscious of what he regarded as his essential differences from Kant. (PD, 334.) Probably all this prevented his appreciating the post-Kantian criticism or seeing its relevance to his own problems. Viewed in the light of Maimon's criticism of Kant, however, Whewell's position is seen to be one of unstable equilibrium. Uncritically, Whewell assumed the existence of things and thoughts, ideas and sensations, as if they were real entities, while his own explicit statements seem to imply the contrary view that they are merely concepts, abstractions from experience.

[3] *Versuch über die Transcendentalphilosophie.* Fischer gives an excellent summary of Maimon's views in his *Geschichte der neuern Philosophie,* Vol. 6, p. 73, in the third edition, Heidelberg, 1900.

The whole crux of the problem for Whewell seemed to lie in the fact that from his, as from the Kantian point of view, the mind must be regarded as an active contributor to all experience. According to English tradition, the mind is passive in sensation. Whewell insisted, on the contrary, that the mind is never a passive recipient of impressions. In a section headed "Reflexion and Sensation," he contrasted his own view with Locke's, observing that their problems were different as well as their solutions of those problems.

"The celebrated doctrine of Locke, that all our 'Ideas' (that is, in his use of the word, all our objects of thinking,) come from Sensation or Reflexion, will naturally occur to the reader as connected with the antithesis of which I have been speaking. But there is a great difference between Locke's account of Sensation and Reflexion, and our view of Sensation and Ideas. He is speaking of the origin of our knowledge;—we, of its nature and composition. He is content to say that all the knowledge which we do not receive directly by Sensation, we obtain by Reflex Acts of the mind, which make up his Reflexion. But we hold that there is no Sensation without an act of the mind, and that the mind's activity is not only reflexly exerted upon itself, but directly upon objects, so as to perceive in them connexions and relations which are not Sensations. He is content to put together, under the name of Reflexion, everything in our knowledge which is not Sensation: we are to attempt to analyze all that is not Sensation: not only to say it consists of Ideas, but to point out what those Ideas are, and to show the mode in which each of them enters into our knowledge. His purpose was, to prove that there are no Ideas, except the reflex acts of the mind: our endeavour will be to show that the acts of the mind, both direct and reflex, are governed by certain Laws, which may be conveniently termed Ideas. His procedure was, to deny that any knowledge could be derived from the mind alone: our course will be, to show that in every part of our most certain and exact knowledge, those who have added to our knowledge in every stage have referred to principles which the mind itself supplied. I do not say that my view is contrary to his: but it is altogether different from his. If I grant that all our knowledge comes from Sensation and Reflexion, still my task then is only begun; for I want further to determine, in each science, what portion comes, not from mere Sensation, but from those Ideas by the aid of which either Sensation or Reflexion can lead to Science." (HSI, I, 33.)

Today, the analysis of knowledge which Whewell proposed would be expressed most naturally in terms of the "subjective"

and "objective" elements of knowledge. At the time Whewell wrote, equivalents for these terms were commonly used by the continental writers, but English thinkers were not generally employing the words "subjective" and "objective" in the sense in which they have now become familiar. (HSI, I, 37.) Whewell, however, found that "this distinction of Subject and Object is one of the most general ways of expressing the fundamental antithesis," and he used these expressions when they were convenient. (PD, 465.) His explanations of the terms presented his dualistic epistemological theory in language which carries more meaning to the modern reader than the less technical phraseology in which Whewell first tried to make clear his conception of the Fundamental Antithesis.

"Hence the part of a man's knowledge which belongs to his own mind, is *subjective:* that which flows in upon him from the world external to him, is *objective.* And as in man's contemplation of nature, there is always some act of thought which depends upon himself, and some matter of thought which is independent of him, there is, in every part of his knowledge, a subjective and an objective element. The combination of the two elements, the subjective or ideal, and the objective or observed, is necessary, in order to give us any insight into the laws of nature." (HSI, I, 35.)

Whewell was not particularly concerned about the precise form of expression which should be used. He dismissed the elaborate new terminology of Fichte, Schelling, and Hegel as of little significance. (HSI, I, 38.) Whewell cared only to make sure that his meaning was clear. By using various expressive phrases, he tried to establish his fundamental conviction that in all experience and in all knowledge there are involved two elements which are commonly contrasted in philosophy but which are necessarily united in experience.

Whewell chose Bacon's thesis: "Man is the Interpreter of Nature," as a heading for a final exposition of his conception of the Fundamental Antithesis. (HSI, I, 41.) The significance of the conception for the understanding of science, as Whewell saw it, is expressed in his further statement that "Science is the right Interpretation." (*Ibid.*) According to Whewell, science implies correct understanding of the real external universe. Science is real because it refers to the external order of things; its

content is objectively determined. On the other hand, science is knowledge because it represents a rational, coherent interpretation of nature made possible by the introduction of *a priori* ideas. Whewell's fellow-countrymen and the sensationalist school of France were emphasizing the objective, sensational element in knowledge. Whewell took the rationalistic view that the subjective, mental contribution is at least as essential to the development of science. He tried to maintain a balanced position in which he could concede to both sources of science their indispensable and complementary contributions. This point of view he tried to make clear in his discussion of various aspects of the Fundamental Antithesis, which he summarized in the following statements, italicized in the original:

"The doctrine of the Fundamental Antithesis is briefly this: That in every act of knowledge (1) there are two opposite elements which we may call Ideas and Perceptions; but of which the opposition appears in various other antitheses; as Thoughts and Things, Theories and Facts, Necessary Truths and Experiential Truths; and the like: (2) that our knowledge derives from the former of these elements, namely our Ideas, its form and character as knowledge, our Ideas of space and time being the necessary forms, for instance, of our geometrical and arithmetical knowledge; (3) and in like manner, all our other knowledge involving a development of the ideal conditions of knowledge existing in our minds: (4) but that though ideas and perceptions are thus separate elements in our philosophy, they cannot, in fact, be distinguished and separated, but are different aspects of the same thing; (5) that the only way in which we can approach to truth is by gradually and successively, in one instance after another, advancing from the perception to the idea; from the fact to the theory; from the apprehension of truths as actual to the apprehension of them as necessary. (6) This successive and various progress from fact to theory constitutes the history of science; (7) and this progress, though always leading us nearer to that central unity of which both the idea and the fact are emanations, can never lead us to that point, nor to any measurable proximity to it, or definite comprehension of its place and nature." (PD, 307.)

Whewell had in mind the contemporary development of the Kantian principles in Germany when he set forth the Fundamental Antithesis in this fashion. He was attempting to make clear his points of agreement and disagreement with some recent exponents of the critical philosophy. For this reason, the analysis of his

doctrine quoted above should probably be regarded as less characteristic than the briefer statement of his conception which is presented in the first aphorism of the *Novum Organon Renovatum:*

"Man is the Interpreter of Nature, Science the right interpretation."

CHAPTER III.

Whewell's Apriorism.

Whewell's definition of science as the *right* interpretation of nature is fundamental to his epistemological theory. From Whewell's point of view, science represents the only possible way of knowing nature. Nature, itself, he sometimes seemed to believe, might have been ordered differently,[1] and then the laws of science would have been correspondingly different. But the universe being what it is, the laws of science represent the only intelligible interpretations of the data which the actually existing order presents for man's apprehension. Since he believed that science presents the only thoroughly comprehensible view of the real world, Whewell concluded that the laws of the inductive sciences may approach the necessity of the laws of mathematics, even though the former are of empirical origin.

In approaching this position, Whewell started from the same question which Kant had proposed. Whewell was a mathematician and physicist of no mean merit. His studies had convinced him that mathematical axioms represent truths which must be recognized by every clear-thinking individual as self-evident and necessary. (HSI, I, 105.) No one, he maintained, could doubt the existence of necessary truths if he were at all familiar with mathematics. Whewell further asserted that certain fundamental principles of physics are as necessary as the axioms of mathematics. In this contention, too, he followed Kant, although he seemed unaware of that fact.[2] Whewell did not regard mathematics as essentially different from the empirical sciences, for in the latter, too, he found that particular conclusions can be rigorously deduced from the definitions and axioms in which the

[1] Cf. citation from the *Bridgewater Treatise,* page 8 above.

[2] In a letter dated September 6, 1837, Whewell remarked that he differed from the Germans in his treatment of mechanics as a necessary science. (IT, II, 259.) The difference is not apparent, however, to one who recalls Kant's assertion that "Mathematics and Physics are the two theoretical sciences which have to determine their objects *a priori.*" (*Critique of Pure Reason,* preface to the second edition.)

Fundamental Ideas of these inductive sciences are made explicit. In his defence of the study of mathematics, Whewell expressed his conviction that the inductive sciences will be found to have much similarity to the deductive sciences when the analysis of scientific knowledge has been thoroughly understood.

"If we neglect to inculcate and require distinctness in the student's apprehension of the idea of force and the resulting principles, the evil in reference to the discipline of the mind is so much the more grievous, in that we thus let slip one of the most favorable opportunities for showing the wide range of mathematical reasoning;—for teaching that the strictest logical necessity, and the most remarkable continuity of deduction are not confined to the domain of space and number only but belong to all subjects on which our notions are sufficiently distinct and precise;—and that the mode in which this rigorous and scientific character may be extended to new subjects is, by making our fundamental ideas so steady and clear, that they may generate in the mind principles, whether definitions or axioms, which may serve as the starting-point of our reasonings."

—*Thoughts on the Study of Mathematics,* Sect. iv.

In this suggestion that universality and necessity may properly be attributed to the laws of the inductive sciences when they are firmly grounded in appropriate first principles, Whewell did seem to be extending the range of certainty beyond what Kant would admit. This would not be surprising if Whewell had merely meant that the logical consequences of general principles may be rigorously deduced regardless of the origin of those principles, but this Whewell expressly did not mean. He emphasized the fact that the first principles must not be regarded as arbitrarily established, but must be recognized as possessing a certain *a priori* necessity. Only then can they be looked upon as foundations for sciences; that is, for the *right* interpretation of nature.

Whewell began with the Kantian problem, how are *a priori* synthetic judgments possible? But he attempted to explain the question in more familiar terms. Instead of referring to the logical distinctions between analytical and synthetic judgments, Whewell tried to make the problem more comprehensible by referring to particular instances in which the apparent necessity of our interpretations must be explained by showing some ground for that necessity. According to Whewell, our unshakable convictions that seven plus three equal ten, that the three angles of a

triangle are equal to two right angles, that reaction must be equal and opposite to action, and that all bodies attract one another with a force proportional to their masses and varying inversely as the squares of the distances between them, all have essentially the same grounds of certainty. Although the last laws cited have been established within historical time, so that their *a priori* necessity cannot be dogmatically asserted, Whewell adduced evidence to prove that these laws, and other laws fundamental in the inductive sciences, come to be regarded as necessary by all those who clearly comprehend them. (PD, 344.) He never questioned the absolute necessity of the axioms and definitions of the Euclidean geometry. Criticism of the number theory and of the laws of logic, such as have appeared in more recent times, would be inconceivable from Whewell's point of view. He was following the critical path in the opposite direction from that proposed in his own day by Lobatschefsky and Riemann, and pursued by Whitehead, Russell, and others at the present time. Far from questioning the necessity of generally accepted principles, Whewell sought to find a firm ground for his conviction that to all of the fundamental and generally recognized laws of the inductive sciences, a similar universality and necessity may be attributed. He wanted to show that the accident of their discovery in relatively recent times does not indicate that they are less truly *right* and *inevitable* interpretations of nature.

Discarding the unfamiliar terminology of the Germans, Whewell stated the Kantian problem in his own fashion:

"The characters of universality and necessity in the truths which form part of our knowledge, can never be derived from experience, by which so large a part of our knowledge is obtained. But since, as we have seen, we really do possess a large body of truths which are necessary, and because necessary, therefore universal, the question still recurs, from what source these characters of universality and necessity are derived." (HSI, I, 68.)

Following Kant, Whewell asserted that certain sciences, most obviously mathematics and physics, rest upon universal and necessary truths. These truths, Whewell pointed out, are not evident to children nor to savages, but only to those who clearly apprehend the relations involved. The truths have been discovered in the course of time, and are recognized by individuals only as the individuals attain to clear conceptions and to habits of clear and cogent

thinking. (PD, 462 ff.) These truths, then, are not analytic judgments; they are synthetic, necessary truths whose necessity is recognized only after they have become familiar. Whewell plainly adopted the Kantian problem for his own, taking care to state it in terms which would lead the reader to discover, in the history of science, inductively established truths whose apparent universality and necessity constitute a problem for epistemology.

Material in the *History of the Inductive Sciences* and in the *History of Scientific Ideas* provided copious illustrations for Whewell's initial assumptions, and also presented the data in such a way as to suggest both the problem and its solution. In the *History of Scientific Ideas,* Whewell discussed the theoretical elements which had been introduced at each great step in scientific progress. In harmony with his conceptions of the Fundamental Antithesis, he emphasized here the subjective, ideal element in knowledge in contrast with the factual elements which he had considered in the *History of the Inductive Sciences,* showing how each element has contributed to the development of scientific knowledge. The problem which he proposed to settle may be most clearly stated in these terms: how are necessary and universal truths possible? (HSI, I, 87.) Whewell answered by reference to the Fundamental Antithesis between sensations and ideas, attributing to ideas the function of making basic scientific principles appear as self-evident to anyone familiar with the ideas.

"To the question just stated, I reply, that the necessity and universality of the truths which form a part of our knowledge, are derived from the *Fundamental Ideas* which those truths involve. These ideas entirely shape and circumscribe our knowledge; they regulate the active operations of our minds, without which our passive sensations do not become knowledge. They govern these operations, according to rules which are not only fixed and permanent, but which may be expressed in plain and definite terms; and these rules, when thus expressed, may be made the basis of demonstrations by which the necessary relations imparted to our knowledge by our Ideas may be traced to their consequences in the most remote ramifications of scientific truth." (HSI, I, 69.)

The differences in Whewell's terminology from that of Kant tend to obscure the similarity of their views, but it is clear from the preceding paragraphs that Whewell followed Kant in attempting to show that the mental element in experience, the contribution of the active mind, is responsible for the universality and necessity

which he attributes to principles of science. Whewell conceded to the Kantian revolution all the significance which Kant had claimed for it. (PD, 222.) He adopted the view that the perfect certainty attaching to the principles of logic, mathematics, and physics can be explained only by regarding the principles as expressions of the *a priori* conditions of understanding. He argued that experience cannot prove universality since it has not tried all cases, and that necessity, as Hume had shown, is not a matter to which experience can testify. (HSI, I, 77.) The question then, as Whewell saw it, was to explain what source of knowledge must be responsible for the necessity which we do apprehend. Whewell accepted Kant's answer in the main but he modified Kant's solution to satisfy his own interpretation of the problem.

" Ideas " in Whewell's epistemology serve like the " forms " and " categories " in Kant's to represent the necessary conditions under which all men are constrained to view the sensory data of science. Whewell made a point of retaining familiar terms when he found them adequate to express his views. (NOR, 290.) He grouped all mental contributions to experience under the term " ideas." He neglected Kant's distinction between the forms of perception and the categories of the understanding. With his emphasis on the function of the ideal element as the basis of the universality and necessity in science, Whewell chose to disregard finer distinctions for the sake of expressing his views in a simple, plausible fashion. If he had accepted Kant's distinction, his readers might have observed that other distinctions between the different Ideas also ought to be noted. Although Whewell endeavored to present an essentially Kantian solution to the Kantian problem, the modifications which he introduced caused some to accuse him of misrepresenting Kant, as Mansel did, for instance;[3] while others, and probably Whewell himself, failed to appreciate his proximity to Kant in matters of detail. (HSI, I, 87.)

The substitution of the term " Fundamental Ideas " for the " forms " and " categories " is more significant than it at first appears to be. Whewell's definition of the term indicates the difference between Kant's transcendental deduction of the categories and his own empirical determination of the Fundamental Ideas. As *Ideas,* these *a priori* elements which Whewell recognized are

[3] H. L. Mansel, *Prolegomena Logica,* Appendix, Note A.

simply the non-sensational constituents of knowledge. As *Fundamental Ideas,* they are regarded as the *a priori* foundations of the sciences. They imply the notions which are made explicit in the definitions and axioms. Whewell referred to the Fundamental Ideas as "Grounds of Scientific Necessity," explaining his meaning variously in order to make his conceptions perfectly comprehensible. (PD, 343.) Sometimes he defined Fundamental Ideas with direct reference to the Kantian view as, for instance, in his discussion of the *Idea of Space.* Again, he defined them in such a way as to suggest the broader development of his own peculiar views, including his conceptions of Ideas as the sources of universality and necessity, and of Ideas as the general notions whose explicit expression and development are essential to the progress of the sciences. This double function of the Fundamental Ideas is suggested in the following paragraph, quoted from a chapter in which Whewell attempted to answer the objections of some contemporary critics.

"The special and characteristic property of all the Fundamental Ideas is what I have already mentioned, that they are the mental sources of necessary and universal scientific truths. I call them *Ideas,* as being something not derived from sensation, but governing sensation, and consequently giving form to our experience;—*Fundamental,* as being the foundation of knowledge, or at least of Science. And the way in which those Ideas become the foundations of Science is, that when they are clearly and distinctly entertained in the mind, they give rise to inevitable convictions or intuitions, which may be expressed as *Axioms;* and these Axioms are the foundations of the Sciences respective of each Idea. The Idea of Space, when clearly possessed, gives rise to geometrical Axioms, and is thus the foundation of the Science of Geometry. The Idea of Mechanical Force, (a modification of the Idea of Cause,) when clearly developed in the mind, gives birth to *Axioms* which are the foundation of the Science of Mechanics. The Idea of Substance gives rise to the Axiom which is universally accepted,—that we cannot, by any process, (for instance, by chemical processes,) create or destroy matter, but can only combine and separate elements;—and thus gives rise to the Science of Chemistry." (PD, 336.)

Whewell separated from Kant on several essential points, but he followed him closely in his discussions of the Ideas of Space, Time, and Cause. (PD, 335.) He defined his use of the term "Idea of Space" so that it appears to be synonymous with Kant's notion of space as a "form of perception."

"By speaking of space as an Idea, I intend to imply, as has already been stated, that the apprehension of objects as existing in space, and of the relations of position, &c., prevailing among them, is not a consequence of experience, but a result of a peculiar constitution and activity of the mind, which is independent of all experience in its origin, though constantly combined with experience in its exercise. . . .

"I assert, then, that space is not a notion obtained by experience. Experience gives us information concerning things without us: but our apprehending them *as* without us, takes for granted their existence in space. Experience acquaints us what are the form, position, magnitude of particular objects: but that they *have* form, position, magnitude, presupposes that they are in space. We cannot derive from appearances, by the way of observation, the habit of representing things to ourselves as in space; for no single act of observation is possible any otherwise than by beginning with such a representation, and conceiving objects as already existing in space." (HSI, I, 91.)

Whewell discussed the Ideas of Time, of Causality, and of Substance again in close adherence to Kant's views. However, Whewell did not discuss these last two as categories of relation, but he made them coördinate with Space and Time as Ideas. Even when he followed Kant so closely in his discussion of these different Ideas, Whewell freed himself from the logical tradition which Kant followed in deducing the table of the categories. Kant clearly stated his conviction that the *a priori* principles of the understanding can all be deduced by the critical method, so that the analysis can be regarded as exhaustive. By assuming that the possible *a priori* categories of the understanding must coincide with the possible forms of judgment, Kant convinced himself that his list of the categories must represent a complete analysis of the *a priori* forms of the understanding. This conclusion may be criticized on the ground that Kant dogmatically assumed the completeness of the classification of judgments when he might more consistently have criticized this, for he did not elsewhere accept as final the *dicta* of the traditional logic.[4]

Whewell, on the other hand, proposed to discover from a history of science what ideas must be regarded as *a priori* in order to explain the development of the inductive sciences. Although he started from the point of view that the universal subjective con-

[4] Cf. Norman Kemp Smith, *A Commentary to Kant's 'Critique of Pure Reason,'* p. 183 ff.

ditions of knowledge are the sources of necessity and universality, Whewell separated from Kant in his method of determining what these *a priori* conditions must be. Whewell derived his list of Fundamental Ideas not by reference to traditional logic, but by studying the history of science. He did not assume that his list was exhaustive and complete, for, unlike Kant, he was content to establish the aprioristic epistemology on an inductive basis without pretending to give an exhaustive analysis of the *a priori* principles of the human understanding. Whewell believed that the history of science must be regarded as an account of the discoveries of the various Ideas fundamental to the different sciences. He regarded discovery of the particular appropriate Idea as essential to the development of each science. A consequence of his view is the conclusion that no list of the Fundamental Ideas can ever be complete while science continues to progress. No new science can be expected to develop on the basis of old Ideas, according to Whewell, for each separate science is distinguished by the peculiar Idea which is found to be required for an understanding of the phenomena which it investigates. This point Whewell illustrated by reference to the abortive efforts to explain physiological phenomena on mathematical principles, on physical principles, or on chemical principles. None of these attempts could possibly be successful, if Whewell's view is correct, for each represented an attempt to apply to essentially different data principles whose sufficiency is limited to the particular fields where they have proved fruitful. (HSI, II, 165 ff.) Moreover, major advances in the established sciences frequently involve the discovery of new Ideas, as, for example, the discovery of universal attraction in the development of the ancient science of astronomy.

The view that the *a priori* constituents of experience have been brought to light in the course of the development of thought, fosters the expectation that other *a priori* Ideas may be discovered in the future. Moreover, it implies that the number of truths recognized as necessary will increase with the progress of science. Since Fundamental Ideas serve as grounds for universal and necessary truths, or at least for truths that approach the universality and necessity of axioms of geometry, and since the development of science has been marked by the discovery of new Fundamental Ideas, it follows that future scientific progress may be expected to involve the discovery of yet unrecognized Fundamental

Ideas, which will provide grounds for recognizing the universality and necessity of the laws which will be deduced from them.

In speaking of the *Ideas of Space, Time,* and *Cause,* Whewell stressed the point upon which Kant founded his critical analysis of knowledge. He spoke of these Ideas as the conditions under which all men are constrained to view the phenomenal world. But in discussing other Ideas, Whewell noted the conditions of their discovery, and took the position that these Ideas represent the conditions under which men *must learn* to view the data of science if they hope to find intelligible explanations of them. In the one case, Ideas appear to be imposed by the nature of the understanding; in the other, the changed emphasis suggests that Ideas are *selected* in order to fit the data. The Ideas selected may not represent the only and immediately necessary ways of regarding the phenomena, but rather the finally successful way of regarding them,—the way which makes it possible to fit all of the data into an intelligible order.

Kant's endeavor to determine the universal conditions of the understanding was quite different, then, from Whewell's effort to establish "the nature and character of the other Scientific Ideas" (i.e., exclusive of the *Ideas of Space, Time* and *Cause*), "by an analysis of the history of the several Sciences to which those Ideas are essential, and an examination of the writings of the principal discoverers in those Sciences." (HSI, I, 87.) Whewell was not so ambitious as to attempt a transcendental deduction of categories. Adopting the methods of science, he endeavored to determine inductively what particular Ideas the development of thought has shown to be fundamental to the various sciences. This fundamental divergence from the critical point of view was perhaps not recognized as such by Whewell, for he appeared to believe that he kept the essentials of the critical position when he insisted that the subjective element in knowledge must be responsible for the universality and necessity which we attribute to certain principles of science. Whewell did recognize, however, that Kant's approach to the problem of discovering the categories was very different from his own and led to dissimilar conclusions.

Whewell regarded the *a priori* elements not as ways of understanding, discoverable in abstraction from all particular content, but as the *right* ways of understanding certain matters. According to Whewell's view, the *a priori* element in knowledge must be

discovered by analyzing the sciences and by noting what elements in them are objective and factual, and which are subjective. Just as the objective data of each science are peculiar to that particular science, so the Ideas by which these data are brought into intelligible relation with one another will be appropriate only to data of the particular sciences to which they are respectively fundamental. Although they are to be regarded as *a priori* conditions of understanding the particular material to which they are applicable, it is unthinkable that they could be enumerated before their discovery in conjunction with that particular content, since, according to the theory of the Fundamental Antithesis, the ideal and sensational elements are necessary complements in experience.

This contention that necessary truth is progressive was heretical from the point of view of those who were inclined to sympathize with Whewell's apriorism only in so far as it was opposed to the empiricism which Mill popularized. Mansel, for instance, in a note on Whewell's Kantian sympathies, expressed a regret that "the accuracy of his theory has been in so many instances vitiated by a stumble on the threshold of the Critical Philosophy."[5] Mansel criticized Whewell for regarding as *a priori*, ideas which are applicable only to certain content, and which the majority of people often have not yet learned to apply even in appropriate cases. It is interesting to note that a German critic, Erdmann, reviewing this controversy between Mansel and Whewell, maintained that the latter was more close to Kant than Mansel. This is particularly curious because Whewell denied that his own philosophy could be fairly interpreted as representative of Kantianism, as Mansel had seemed inclined to treat it, while he referred to Mansel as "by much the most zealous English Kantian whose writings I have seen." (PD, 335.) According to Erdmann, Whewell was in agreement with Kant in ascribing an *a priori* necessity to the law of the conservation of matter and to the law of the equality of action and reaction, while Mansel, on the other hand, treated these laws as of purely empirical origin, denying that Substantiality, Causality, and Reciprocity are properly regarded as categories of the understanding.[6]

Mansel believed that it is desirable to retain the customary dis-

[5] H. L. Mansel, *Prolegomena Logica*, Appendix, Note A.

[6] Erdmann, *Deutsche Philosopheme und britische Philosophen, Zeitschrift für Philosophie und Philosophische Kritik*, 1857, Vol. 30, pp. 90–100.

tinctions between "Mathematical, Metaphysical and Logical Necessity," and "Physical Necessity, or belief in the permanence of the Laws of Nature." He agreed with Whewell in regarding the former kinds of necessity as dependent on the constitution of the human mind; but with Mill, he contended that the apparent necessity of the laws of nature is founded on mere belief, based on invariable experience. Such a belief is not to be explained by an epistemological analysis of the powers of the knowing mind, according to Mansel, but rather by a psychological study of the laws of mental action. Thus Mansel denied Whewell's fundamental assumption that a "new Organon" was needed to explain the *a priori* necessity which Whewell attributed to the fundamental principles of the physical sciences.[7]

The heresy that the laws of the physical sciences are necessary in the same sense that the laws of mathematics and logic are necessary was defended in England by Whewell alone. Even he did not succeed in making a perfectly consistent defense. Objections which were offered to his conclusions were frequently not inharmonious with some of his own views. Mansel's assertion that no statements of physical fact can be regarded as more than contingent, sounds as if it might have been taken from Whewell's own *Bridgewater Treatise:* "However rigidly certain phenomena may be deduced from the assumption of a general law of nature, the law itself remains nothing more than an observed fact, of which we can give no other explanation, than that it was the will of the creator to constitute things in a certain manner." [8]

Mansel's criticism of Whewell's views was not so effective in alienating popular sympathy from Whewell as was the criticism of John Stuart Mill. Mill criticized Whewell's rationalistic premise that the laws of science are expressions of *a priori* conditions of thought. He suggested that Whewell's conception of a necessary truth might be expressed most simply by the definition, "a proposition the negation of which is not only false but inconceivable." [9] Whewell accepted this definition with an amendment: "we cannot *distinctly* conceive the contrary of a necessary truth. For in a certain loose, indistinct way, persons conceive the contrary of necessary geometrical truths, when they erroneously

[7] Mansel, *Prolegomena Logica,* Chapter iii.

[8] *Op. cit.,* chapter v.

[9] J. S. Mill, *System of Logic,* Book II, chapter v, section 6.

conceive false propositions to be true." (PD, 463.) In accepting this criterion of necessity, Whewell seemed to acknowledge that the distinction between necessary and empirical truths is psychological rather than logical. At least Spencer and Mill easily found a psychological explanation for our inability to conceive the contrary of propositions which are unfailingly exemplified in experience, and they proceeded to give an empirical ground for the apparent necessity of such propositions.[10] Whewell, of course, meant to defend the rationalistic point of view that the necessity of truths depends upon the fact that they are expressions of *a priori* principles of reason. The proposition that no man can clearly conceive the contrary of a necessary truth follows logically from this rationalistic premise, but it cannot be taken as providing a criterion of necessity without betraying rationalism into the hands of the enemy.

Whewell gave up the traditional clear distinction between necessary and empirical truths when he admitted that scientific generalizations approach the character of necessary truths by virtue of the Fundamental Ideas which they involve. (HSI, I, 67.) When Whewell considered this notion in conjunction with the criterion of necessary truth which he had accepted from Mill, he was enabled to describe in more detail how scientific generalizations attain the appearance of necessary truths. According to Whewell, scientific discovery depends upon the intuiting of the Fundamental Idea by which the facts can be brought into intelligible relation with one another. When the new point of view has become familiar, the facts can no longer be viewed as the unrelated data which they at first seemed to be. The new interpretations appear to be necessary and inevitable ways of regarding the phenomena; the contrary of the recently recognized truths can not be distinctly conceived. (NOR, 32.) Whewell found plenty of evidence in the history of science to support his contention that truths actually discovered in historic time, and even by known individuals, have come to be regarded as indubitable. Copernicus' heliocentric theory is now considered as a necessary conclusion from the facts; the elliptical paths of the planets now appear so obvious that Kepler's discovery has been called a mere description; Newton's conception of universal gravitation has been considered a necessary pre-

[10] *Ibid.;* Herbert Spencer, *The Universal Postulate, Westminster Review,* 1853. Vol. 60, pp. 269–288.

mise in any physical discussion,—so Whewell could argue.[11] The explanation of this gradual approach to certainty was given by Whewell in terms of his rationalistic theory: the Fundamental Ideas which are involved in the statement of new scientific laws are *a priori* in the human mind, and require only to be made explicit to be recognized. Furthermore, as *a priori,* these Ideas guarantee the necessity of laws in which they are expressed. Whewell seemed to believe that the criterion of inconceivability of the contrary is convenient for distinguishing those laws which involve Fundamental Ideas from those which are merely generalizations from facts. Mill[12] ridiculed the notion that truths admittedly discovered in the course of experience can be considered as necessary truths. The necessity, he claimed, is a mere illusion. Because our habits of viewing things from certain points of view are so well established, and are continually justified in practice, we cannot, in fact, take a contrary point of view. But this inability cannot be cited as evidence in behalf of Whewell's apriorism; it is obviously due only to the invariability of experience. Answering in this fashion, Mill succeeded in conveying the impression that Whewell's theory of necessity rested on false premises. Whewell seemed compelled to defend his position by appealing to the argument that there is nothing essentially absurd in the contention "that the laws of Mechanics, and even the laws of the Chemical Composition of bodies, may depend upon principles as necessary as the properties of space and number," and by asserting his conviction that such principles "may be much better described as conditions of experience, than as results of experience:—as laws of the mind and of its activity, rather than as facts impressed upon a mind merely passive." (PD, 287, 288.) Certainly Whewell's admissions in this controversy about the necessity of basic scientific principles revealed the weaknesses of any version of rationalism which maintains the *a priori* character of particular conceptions, such as are included among Whewell's Fundamental Ideas.

The general favor with which Mill's empiricistic views were received in England seemed to put Whewell in the position of one who was defending a lost cause. Whewell's notions were not so readily dismissed in Germany, however, for his position repre-

[11] Cf. above, page 27 ff.
[12] *Ibid.*

sented a development of Kantian principles which was more in harmony with the philosophical tradition of Kant's countrymen than was the empiricism of Mill and Herschel.[13] In a review entitled *Die sogenannte induktive Logik,* Ulrici referred to Whewell as Mill's opponent and quoted some of Whewell's remarks on universal and necessary truths as principles which Whewell maintained *"in Uebereinstimmung mit allen deutschen Philosophen seit Kant."*[14] Ulrici was referring to Whewell's assertion that the universality which we attribute to axiomatic truths can never be derived from experience. He also quoted what he regarded as Mill's astounding reply that the universality and necessity which Whewell attributed to the laws of nature is an illusion, due only to man's preceding experience and mental habits. This contention of Mill's which was so congenial to English tradition, and in contradiction to which Whewell defended his own apriorism seemed to this German critic to represent a refusal to meet essential problems. In agreement with Whewell, he maintained that Mill's empiricistic views represented an unsuccessful effort to evade problems rather than an attempt to solve them. Ulrici's criticism indicated that Mill's empiricism was in as ill accord with the German traditions of rationalism and idealism as Whewell's apriorism was with the empirical tradition of British philosophy.

Whewell found no converts to his peculiar point of view. The logician Mansel denied that the formal validity and necessity which belong to the truths of mathematics and logic can be claimed for the fundamental principles of the inductive sciences. Mill and the other empiricists agreed that Whewell was wrong in attributing to these laws a universality and necessity which cannot be derived from mere experience. On the other hand, Whewell denied that experience, even uniform and invariable experience, can account for the apparent necessity of first principles. Mill asserted that necessity is *only* apparent, that it is, in fact, an illusion. He accepted in the main Dugald Stewart's contention that the necessity of the pure sciences is a consequence of rigorous deduction from *hypothetical* first principles. He refused agree-

[13] In his *Preliminary Discourse on the Study of Natural Philosophy,* published in 1830, Herschel took the empiricistic position which Mill developed more fully in his *System of Logic.*

[14] *Zeitschrift für Philosophie und Philosophische Kritik,* 1852. Vol. 21, p. 176.

ment to Whewell's opposed contention that the pure sciences must rest upon *a priori* grounds which guarantee them a necessity of no arbitrary sort.[15]

Whewell explained his theory that the Fundamental Ideas underlying the natural sciences are the basis of *a priori* universal and necessary truths, by showing that these principles, once discovered, are assumed without verification in any future reasonings. Their truth is recognized immediately, and critical analysis of the sort that Whewell presented in the *History* and *Philosophy of the Inductive Sciences* reveals the fact that these principles represent assumptions which are logically essential to the further development of their respective sciences. Whewell's *Demonstration that All Matter is Heavy* (PD, 522 ff.), presents a clear statement of his position on this point. Historically, the theory of phlogiston represented an attempt to introduce into science the conception of an element "with positive levity instead of gravity." (PD, 523.) But although the promulgation of this theory proves that the notion of matter without weight has not been utterly inconceivable, Whewell maintained that "it may be that there is an absolute impossibility of conceiving matter without weight; but then, this impossibility may not be apparent, till we have traced our fundamental conceptions of matter into some of their consequences." (PD, 525.) The gist of Whewell's argument is that it is necessary to conceive all matter as having weight because that notion is implied in fundamental laws of physics and of chemistry. Modern rationalists have used similar arguments to prove that such fundamental conceptions are merely postulates of maximal fruitfulness, but Whewell considered that his conclusion follows necessarily "from those fundamental ideas which we unavoidably employ in all attempts to reason concerning the mechanical relations of bodies." (PD, 530.)

Vaihinger's suggestion that similar "fundamental principles" are in fact scientific fictions, logically implied in the further development of the sciences but not therefore more than practically useful postulates, was a suggestion not proposed by any of Whewell's contemporaries, except in so far as Dugald Stewart's assertion of the hypothetical basis of mathematics was similar. The answer which Whewell gave to a defendant of Stewart's views suggests the response which he would make to more systematic

[15] *Op. cit.*, Book II, chap. v.

and inclusive theories of the type presented by Vaihinger. It amounts merely to a dogmatic assertion that universal and necessary truths do represent the *only* possible ways of understanding things and that they are not arbitrarily selected from a number of possible ways.

"I had dissented from Stewart's assertion that mathematical truth is hypothetical, or depends upon arbitrary definitions; since we understand by an hypothesis a supposition, not only which we may make, but may abstain from making, or may replace by a different supposition; whereas the definitions and hypotheses of geometry are necessarily such as they are, and cannot be altered or excluded. . . . (HSI, I, 107.)

This assertion of the *a priori* necessity of mathematical axioms and definitions and the belief that the fundamental laws of the inductive sciences approach these in certainty represent the fundamental assumptions upon which Whewell's theory is based. His defence of his view that necessary truth is progressive gives his explanation of the fact that discoveries made within historical time, and even by his own contemporaries, may reveal the first principles upon which the future development of the inductive sciences will depend, just as geometry depends upon the *Ideas of Space* and upon the axioms and definitions derived from it. Whewell's theory of Fundamental Ideas as the foundations of the inductive sciences implied that all of these Ideas represent laws of thought under which men must regard the relevant facts if they are to comprehend them clearly,—if, indeed, they are to find them intelligible. Whewell admitted that *Space* and *Time* represent Ideas under which all men are constrained to perceive all things, and he recognized the fact that other Ideas (e.g., the *Idea of Mechanical Force,* and the *Idea of Substance*), are not so universally applied. He pointed out, however, that Ideas become the bases of sciences only when they are clearly apprehended, and that the *Idea of Space,* like those discovered later, has not always been familiar in the form in which it becomes the basis of geometry. The *Idea of Space* is applied without scientific precision among "uncultivated savages" and among children. These last perceive things under the form of space, of course, but in the same vague way that those unfamiliar with the sciences of chemistry and physics apply the *Idea of Substance* and the *Idea of Mechanical Force.* The difference in our familiarity with

these different Ideas is only one of degree, according to Whewell. He believed that once the Ideas are "clearly and distinctly possessed" they can never be lost sight of, and they influence all subsequent perceptions just as the more elementary *Ideas of Space* and *Time* have done. (PD, 336 ff.)

As one of his contemporary critics pointed out, Whewell made no distinction "between the necessary laws under which all men think and the contingent laws under which certain men think of certain things."[16] The denial of this distinction in its essential significance was in fact a cardinal point in Whewell's philosophy. He was concerned to explain how the inductive sciences can boast laws which approach the axioms of the pure sciences in simplicity and universality, and he rested his case on the explanation that such laws are expressions of the Ideas which have been discovered to be fundamental to the respective sciences, just as the axioms of geometry are expressions of the *Fundamental Idea of Space.* Whewell explained his contention that truths discovered in the course of scientific development may be regarded as necessary, by assuming the essential similarity between the Fundamental Ideas from which they are derived and the Fundamental Ideas which, according to his view, guarantee the necessity of arithmetical equations and of geometrical propositions.

The history of science, from Whewell's point of view, is a history of the discovery of Fundamental Ideas and the elucidation and verification of their consequences in the explanation of natural phenomena. From the point of view of the race, recognition of fundamental truths is progressive, just as it is from the point of view of the maturing individual. Whewell repeatedly asserted that the universality and necessity of the axioms derived from the Fundamental Ideas is not apparent at once and to all men. The apprehension of them as necessary comes only as the conclusion of a process of growing comprehension of the ideas. Just as the individual gradually attains to that clear apprehension of the *Idea of Space* which enables him to appreciate the self-evidence of the axioms of geometry and the cogency of geometrical demonstrations, and then, if he is of a scientific turn of mind, gradually acquires similarly clear Ideas fundamental to the other sciences; so in the history of scientific development, Ideas have been discovered, and gradually people have apprehended them

[16] H. L. Mansel, *Prolegomena Logica,* Appendix, Note A.

in their full significance, and have developed their implications for science. The process of clarification of Ideas is exemplified in the race as well as in the individual, for the first announcement of a new discovery is frequently, almost characteristically, attended with criticism and controversy which ends only when those prepared to judge agree in recognizing the sufficiency and significance of the new Idea. Whewell maintained, in opposition to Mansel as well as to contemporary empiricists, that the fundamental principles which have come to be recognized as such only when the clouds of controversy have blown away, are to be regarded as axiomatic. To his critic's assertion that no truths could legitimately be regarded as necessary whose truth had in fact been questioned, Whewell answered with a flat contradiction:

"That some steady thought, and even some progress in the construction of Science, is needed in order to see the necessity of the Axioms thus introduced, is true, and is repeatedly asserted and illustrated in the History of the Sciences. The necessity of such Axioms is seen, but it is not seen at first. It becomes clearer and clearer to each person, and clear to one person after another, as the human mind dwells more and more steadily on the several subjects of speculation. *There are scientific truths which are seen by intuition, but this intuition is progressive.* This is the remark which I wish to make in answer to those of my critics who have objected that truths which I have propounded as Axioms, are not evident to all." (PD, 343.)

By adopting as a positive tenet the view that "Necessary Truth is Progressive," Whewell attempted to reconcile his apriorism with his appreciation of the evolution of scientific thought. (PD, 347 ff.)

When Whewell first propounded the theory of "Fundamental Idea-ism" as a conclusion from his survey of the history of the inductive sciences, he apparently failed to recognize the fact that he was approaching close to the Platonic doctrine of Ideas. Whewell asserted his conclusion as a discovery, and he was not concerned to search out suggestions of the same notion among earlier writers. Even in those critical reviews which became the frame-work of the *Philosophy of Discovery,* Whewell showed little appreciation of Plato's views. He spoke of Plato as one who "shared in a dimness of vision which prevailed among philosophers up to the time of Francis Bacon." (PD, 10.) This phrase he retracted in the "Additional Remarks on Plato," which

he introduced as chapter three of the *Philosophy of Discovery.* (PD, 13 ff.) Moreover, Whewell pointed out there the parallels between his own conclusion that the grounds of necessary and universal truths must be sought in *a priori* Ideas, and Plato's doctrine that only Ideas can give certain and permanent knowledge. According to Whewell, the Platonic Theory of Ideas was primarily designed to answer the same problem which Whewell himself, following Kant, had undertaken to solve.

"... The sciences of Geometry and Arithmetic show that there *are* truths which man can know; and the Doctrine of Ideas explains how this is possible.

"So far the Doctrine of Ideas answers its primary purpose, and is a reply (by no means the least intelligible and satisfactory reply) to a question still agitated among philosophers: What is the ground of geometrical (and other necessary) truth?" (PD, 13.)

Whewell did not fail to criticize certain points of the Platonic doctrine, as for instance, the implication that we may have Ideas of tables and of chairs, and he noted Plato's failure to distinguish between Ideas as generic concepts and Ideas as laws exemplified in phenomena. (PD, 13.) On the whole, however, Whewell seemed to have become aware in the interval between the publication of the second and the third editions of the *Philosophy* that his own theory was essentially Platonic.[17] The contention that sensations cannot be the source of certain knowledge is one that Whewell wholly embraced, although his own realistic inclinations made him deny Plato's grounds for their common conclusion. In opposition to Plato, Whewell maintained that ideas and sensations are not separable as Plato seemed to believe, but that they are inseparable poles of the Fundamental Antithesis, and that neither is ever found without the other. (PD, 424.) Whewell believed that the world of nature is knowable, but that it must be interpreted in the light of the Fundamental Ideas which make possible an intelligible view of the formless data provided by the senses. This conviction that the principles of intelligibility are *a priori* in the human mind separated Whewell from the majority of his British contemporaries. On the other hand, Whewell was distinguished from the Kantians by his belief that these principles have

[17] The first four of the essays appended to the *Philosophy of Discovery* further indicate that Whewell's interest in Plato was not confined to his moral theories as Todhunter seemed to believe. (IT, I, 132.)

been progressively discovered, and that others will very likely be discovered in the future. Whewell finally adopted an interpretation of the Platonic doctrine which agreed with his own views on both of these points. He included in his supplementary chapter on Plato a restatement of the Platonic doctrine which makes that doctrine appear to be in its epistemological aspects an early anticipation of views which Whewell had arrived at independently by his survey of the history of the inductive sciences.

"I may, as further bearing upon the Platonic notion of science, notice Plato's view of the constitution of the human mind. According to him the Ideas which are the constituents of science form an Intelligible World, while the visible and tangible things which we perceive by our senses form the Visible World. In the visible world we have shadows and reflections of actual objects, and by these shadows and reflections we may judge of the objects, even when we cannot do so directly; as when men in a dark cavern judge of external objects by the shadows which they cast into the cavern. In like manner in the Intelligible World there are conceptions which are the usual objects of human thought, and about which we reason; but these are only shadows and reflections of the Ideas which are the real sources of truth. And the Reasoning Faculty, the Discursive Reason, the *Logos,* which thus deals with conceptions, is subordinate to the Intuitive Faculty, the Intuitive Reason, the *Nous,* which apprehends Ideas. This recognition of a Faculty in man which contemplates the foundations—the *Fundamental Ideas*—of science, and by apprehending such Ideas, makes science possible, is consentaneous to the philosophy which I have all along presented, as the view taught us by a careful study of the history and nature of science. That new Fundamental Ideas are unfolded, and the Intuitive Faculty developed and enlarged by the progress of science and by an intimate acquaintance with its reasonings, Plato appears to have discerned in some measure, though dimly. And this is the less wonderful, inasmuch as this gradual and successive extension of the field of Intuitive Truth, in proportion as we become familiar with a larger amount of derived truth, is even now accepted by few, though proved by the reasonings of the greatest scientific discoveries in every age." (PD, 17.)

The criticism which Whewell expressed in regard to Plato's notion of Ideas is not always inapplicable to his own theory, at least in a general way. For instance, Whewell's complaint that Plato's use of the term "Idea" is not perfectly clear and consistent is one which every reader of Whewell must feel is equally applicable to the critic. Whewell varied his forms of expression almost endlessly, in order to make clear to an unsympathetic pub-

lic just what he meant by insisting that the discovery of the appropriate Fundamental Ideas is a necessary condition of the development of the sciences. In order to show how this view met the problem raised in the Kantian criticism, he defined "Ideas" in the sense of Kant's categories, as "universal forms of intuition." (PD, 530.) This interpretation represents the view which Whewell's conception of his problem first suggested, for the explanation that the Ideas are the forms under which all men by their very natures are constrained to view phenomena seemed to provide a solution to the question: How are universal and necessary truths possible?

As Whewell departed from Kant, however, and sought to show how the Fundamental Ideas underlying each of the inductive sciences provide for their approaching the same universality and necessity which traditionally had been conceded to the "pure sciences," he seemed to modify his notion of Ideas. Ideas became, not the universal conditions under which all men are constrained to view all things, but rather points of view from which certain things may be rightly understood. The ideas are regarded as necessary to a *right* interpretation of nature, but usually many interpretations are attempted before the appropriate Idea is discovered, and some of these may be generally accepted until their falsity is recognized in the light of the right Idea. Seen in their newly discovered relations to one another, the phenomena may appear to be transformed, for they can never again be apprehended as the unrelated events which they had previously appeared to be. (NOR, 76.) In this way, the newly discovered Ideas function like the Kantian forms and categories, for they determine subsequent experiences just as inevitably when they have once been clearly grasped. The distinction seemed to Whewell much less significant than the similarity in this case. He believed, apparently, that his various definitions of Ideas presented no essential distinctions of meaning, but rather differences of emphasis which, taken together, gave more adequate expression to his notion.

A more significant variation in Whewell's interpretation of Ideas was his failure to maintain the distinction between Ideas and conceptions in his discussion of particular sciences. The general distinction between them at first seems to be perfectly clear: Ideas represent general points of view or systems of relations; conceptions are particular determinations of Ideas. In his

"Analysis of the Process of Induction" (NOR, 186 ff.), Whewell defined the difference very clearly:

"It will be recollected that by the word *Idea* (or Fundamental Idea,) used in a peculiar sense, I mean certain wide and general fields of intelligible relation, such as Space, Number, Cause, Likeness; while by *Conception* I denote more special modifications of these ideas, as a *circle*, a *square number*, a *uniform force*, a *like form* of flower." (NOR, 187.)

When Whewell considered particular notions, however, he was not careful to maintain the distinction, and it seems improbable that he could have kept it without appearing needlessly dogmatic. For instance, he referred sometimes to the *Idea of Number* (NOR, 8; 167), sometimes to the *Conception of Number* (HSI, I, 137; 142), regarding it in the latter case as a particular modification of the *Idea of Time*. Again, in his discussion of a *First Cause*, he refused to consider the question whether the designation *Idea* or *Conception* was the more proper. (NOR, 137.)

"I have, however, spoken of our *Conception* rather than of our *Idea* of a First Cause; for the notion of a First Cause appears to be rather a modification of the Fundamental Idea of Cause, which was formerly discussed, than a separate and peculiar Idea. And the Axiom *that there must be a First Cause*, is recognized by most persons as an application of the general Axiom of Causation, *that every effect must have a Cause;* this latter Axiom being applied to the World, considered in its totality, as a single Effect. This distinction, however, between an Idea and a Conception, is of no material consequence to our argument; provided we allow the maxim, that there must be a First Cause, to be necessarily and evidently true; whether it be thought better to speak of it as an independent Axiom, or to consider it as derived from the general Axiom of Causation." (HSI, II, 321.)

It appears evident that Whewell failed to establish a list of the Fundamental Ideas, even of those that he regarded as established up to his own time, in part, at least, because he could not always decide whether particular notions were to be accorded the full dignity of Fundamental Ideas or whether they might better be regarded as modifications of other Ideas. Where he did list the Ideas which he recognized, he showed a freedom from restricting consistency which puzzles the reader who would discover just what those Ideas are the discovery of which, according to Whewell, has marked the great advances in each field of science. Some

interesting differences are revealed by a comparison of the list included in the preface to the third edition of the *History of Scientific Ideas* with that "previous enumeration of Ideas" which concluded the first book of the first volume (HSI, I, 82), and with the list given in the *Novum Organon Renovatum* (NOR, 140). Many Ideas are common to the three lists: *Space, Time, Number; Cause, Force, Matter; Medium* (or *Media*); *Polarity, (Chemical) Affinity, Substance, Symmetry; Likeness* (or *Resemblance*), *Natural Classes* (or *Natural Affinity*); *Vital Forces* or *Powers* (or *Assimilation and Irritability*), *Final Causes* (or *Final Cause*); *Historical Causation.*[18] In the original list there had been included also the *Idea of the Externality of Objects,* and in the *Novum Organon Renovatum,* the same Idea was included as *Outness.* Perhaps Whewell realized that this notion was only implicitly recognized in most cases, and that few would admit it as a Fundamental Idea of science. At all events, Whewell dropped this in the later list of his Ideas. *Motion, Intensity, Scale, Element, Atom, Likeness, (Degrees of Likeness),* and *First Cause* were all included in the more extensive lists in the *Novum Organon Renovatum* and in the main body of the *History of Scientific Ideas.* A final comparison of the various lists shows that *Life, Function, Catastrophe and Uniformity* appear first in the preface to the History while there is no mention there of certain Ideas included in the table found in the same volume: namely, the Ideas of *Sign, Limit, Inertia, Fluid Pressure, Organization, Instinct, Emotion,* and *Thought.* Perhaps the implication was that these can be omitted from any but a list that purports to be complete, but since certain Ideas were added for the first time in the last written list it seems more probable that Whewell's notions varied more or less from time to time, and that he did not trouble to revise the lists which had appeared in earlier editions. In the preface to the *History of Scientific Ideas,* the enumeration follows the statement, "The ideas of which the History is here given are mainly the following." The implication seems to be that other Ideas might have been in-

[18] Parenthetical inserts represent the form in which the Ideas are presented in the list which appeared in the main body of the *History of Scientific Ideas.* This list and the one in the *Novum Organon Renovatum* first appeared in the *Philosophy of the Inductive Sciences.* The list included in the preface to the *History of Scientific Ideas* was introduced in the third edition. The order of their composition was probably: HSI, I, 83; NOR, 140; Preface to HSI.

cluded in a more exhaustive discussion. Probably Whewell never set down what he would regard as a complete list of the Fundamental Ideas.

Whewell seemed to vary his notion of just what is included among the Fundamental Ideas according to his preoccupation of the moment. When he was concerned to regard Fundamental Ideas as the grounds of necessary truths, he spoke in terms of such Ideas as *Space, Time* and *Cause;* but when he considered the Fundamental Ideas which seemed to him to have contributed to the development of each of the special sciences, he referred to conceptions which seem peculiar to those sciences and even to particular theories which have been generally accredited. The most curious example of this extension of the term is in his inclusion of *Catastrophe and Uniformity* as a Fundamental Idea. It is rather puzzling to know just what Whewell meant by grouping together as one Fundamental Idea the opposed conceptions of the catastrophic and uniformitarian schools of geology. Obviously, he was venturing into disputed territory, and he seemed inclined to claim support for his own compromise position by elevating these conceptions together to the rank of a Fundamental Idea.[19]

This tendency to include Ideas of increasing determinateness and specificity of application is indicative, first, of Whewell's recognition that certain sciences, and the Ideas upon which they depend, are fundamental to other sciences; second, that Whewell's conception of the function of Ideas in his system changed slightly as he tried to show how the particular sciences exemplify the Fundamental Antithesis and to establish the *a priori* character of the Ideas upon whose discovery their development has depended.

In regard to the first point, it may be remarked that Whewell shared Comte's view that certain sciences, like geometry and arithmetic, are fundamental to others which are developed later. He further explained what he regarded as the logical, as well as the chronological, priority of the former by showing that the Ideas involved in them are not only more familiar than the Ideas peculiar to the later developed sciences, but that the earlier Ideas are also

[19] Whewell attempted to show that there is no essential difference between the uniformitarian and catastrophic explanations. His contention was that the admission of causal events of such magnitude as to produce the phenomena which the geologists attempt to explain is equivalent to the admission of catastrophes even though the events are similar in kind to those which are now found in operation.

involved in the more recently developed sciences and are essential, but not sufficient, for their progress. A further point, and one on which Whewell put more explicit emphasis, was his view that "the Ideas of Time, Number, and Space, are Ideas possessing peculiar definiteness and precision; so that with regard to them, confusion and indistinctness are hardly possible." (NOR, 61.) To this extent he admitted a difference between these Ideas and those others which have been established after discussion and controversy.

The second point is in line with a criticism of Whewell's apriorism which has been touched upon in earlier parts of this chapter. It is clear that Whewell's conception of the Fundamental Ideas varied according to whether he was concerned with them as the grounds of universal and necessary truths, or as the relating elements in experience. The difficulty, as Todhunter pointed out, was mainly that Whewell tried to carry over into the inductive sciences the notions which he had acquired from his study of the deductive sciences. (IT, I, 109.) There he had discovered that certain fundamental principles follow necessarily from Ideas of Space and Number which, he believed, could not conceivably be other than they are. But the inductive sciences also are grounded in principles which come to appear to the cultivators of those sciences to be as indubitable as the first principles of geometry and arithmetic. These principles, however, are not merely precise determinations of notions under which all men view the phenomena from the beginning; but they are discovered in the effort to find some means of relating given phenomena into a coherent system. In contrast with contemporary empiricists, Whewell insisted that these relating conceptions, although discovered in the course of experience, must be *a priori* in the human mind. In analogy with his original argument that the universality and necessity of the truths of the deductive sciences can be accounted for only by accepting the Kantian point of view that there must be "Necessary conditions of Knowledge, universal forms of intuition, inherent types of mental development," common to all men (PD, 530), Whewell proceeded to develop the view that there must similarly be *a priori* conditions determining the possibility and manner of perceiving phenomena which are data for the inductive sciences. This, as the previous discussion has indicated, was the original point of view from which Whewell proceeded in the development

of his apriorism. But there was another aspect of his thought which received less emphasis, although it explains Whewell's conception of the Fundamental Ideas which tended to replace that view of these Ideas which he borrowed directly from Kant. This was the notion that Ideas are the relating elements of science, for which sensations provide the disconnected data.

"Our sensations require ideas to bind them together, namely, ideas of space, time, number, and the like. If not so bound together, sensations do not give us any apprehension of things or objects. All things, all objects, must exist in space and in time—must be one or many. Now space, time, number, are not sensations or things. They are something different from, and opposed to sensations and things. We have termed them ideas. It may be said they are *relations* of things, or of sensations. But granting this form of expression, still a *relation* is not a thing or a sensation; and therefore we must still have another and opposite element, along with our sensations. And yet, though we have thus these two elements in every act of perception, we cannot designate any portion of the act as absolutely and exclusively belonging to one of the elements. Perception involves sensation, along with ideas of time, space, and the like; or, if any one prefers the expression, involves sensations along with the apprehension of relations. Perception is sensation, along with such ideas as make sensation into an apprehension of things or objects." (PD, 467.)

This view may appear to be essentially the same that Whewell had proposed all along. Ideas are the form-giving elements of experience, introduced by the knowing subject to make of the formless matter of sensation a comprehensible whole. Yet there is a distinction, for Ideas of Space, Time, and Number, are applied to sensory data immediately and by all men, while the Ideas of the more recent sciences are consciously sought by men who would find an intelligible explanation of phenomena, and their success is recognized by their finding it possible to make of the unrelated data a coherent whole.

Starting from the notion that things can only be apprehended under the *a priori* forms of perception and categories of the understanding, Whewell arrived at the conviction that events can be intelligibly related into the coherent bodies of knowledge which science represents, only by the introduction of principles of order, which must be intuitively *discovered,* although they are *a priori* in the human mind. This position amounts simply to the assertion that all principles of intelligibility are contributed by the knowing

mind. The idealistic conclusion that things in themselves are incomprehensible is one which Whewell refused to accept, for he assumed that science represents the *right* interpretation of an external universe and that man has been endowed by a beneficent Deity with the *a priori* Ideas which are the necessary conditions of rightly understanding nature. Whewell's rationalism necessitated this recourse to an assertion of faith, because he had to explain how the *a priori* Ideas can provide means of understanding relations between things. His conviction that a beneficent Deity must be responsible for the perfect harmony of the *a priori* mental order and the physical order found in nature represented the only answer which Whewell could propose in an attempt to save his rationalism from the objections of his empirically minded critics. This point, and the analysis of the process of induction which led up to it, will be considered more fully in succeeding chapters.

CHAPTER IV.

The Process of Discovery.

Whewell undertook the writing of a *History* and *Philosophy of the Inductive Sciences* with the idea of providing an account of the manner in which science has actually progressed, and of discovering from this review what means may be employed in future investigations with some hope of success. However, Whewell concluded that Bacon, in whose work he had found the inspiration to his own task, had failed to establish "the *Organ* by which truth is to be collected from nature," not only because of the fact that Bacon had to speculate without guidance from past progress in science, but also because Bacon hoped too much from mere method. Whewell's historical survey convinced him that "an Art of Discovery is not possible." (NOR, v.)

"We may hope in vain, as Bacon hoped, for an Organ which shall enable all men to construct Scientific Truths, as a pair of compasses enables all men to construct exact circles. This cannot be. The practical results of the Philosophy of Science must be rather classification and analysis of what has been done, than precept and method for future doing." (NOR, v.)

This rejection of Bacon's undertaking was not more than a cautious limitation of the achievement to which any writer of a "Newer Organ" might reasonably aspire. Whewell did not feel that he was leaving Bacon's project for another to accomplish. On the contrary, he seemed satisfied that he had successfully "renovated" the Baconian "Organ" in accordance with all the evidence which had been provided by the scientific developments in the intervening centuries.

"I have only to repeat what I have already said; that this task of adapting the *Novum Organum* to the present state of Physical Science, and of constructing a *Newer Organ* which may answer the purposes at which Bacon aimed, seems to belong to the present generation; and being here founded upon a survey of the past history and present conditions of the Physical Sciences, will I hope, not be deemed presumptuous." (NOR, xii.)

The essential problem which Whewell undertook to settle was

the determination of the processes by which scientific discoveries have actually been made. His *History of the Inductive Sciences* provided a wealth of material which Whewell seemed to regard sometimes as data from which to draw his conclusions, sometimes as illustrations of the processes which, he believed, must be involved in any scientific advance. (IT, II, 284.) The first view is alone consistent with Whewell's repeated assertion that he based his philosophy of science upon an historical survey of all of the inductive sciences up to his own time, so that his view represented an induction from the assemblage of available materials. The alternative view is one which Whewell would have resented, very likely, if it had been expressed by one of his contemporary critics, but which is suggested by his own express admission that the *History* and the *Philosophy* were written simultaneously and from the same survey of historical accounts. (PD, 345.) The fairest conclusion seems to be that Whewell was guided in his selection and organization of historical data by a conviction that the apparent universality and necessity of various fundamental laws of science must be due to an *a priori* element which has combined with the data of experience to yield explanatory laws. However, in his more detailed statement concerning the means by which scientific laws have been discovered and established, Whewell drew his conclusions from his investigation of the actual, historical course of scientific progress. His belief that the discovery of the Fundamental Ideas appropriate to the particular sciences is essential to the development of those sciences, although illustrated by reference to the history of science, was grounded in a very different sort of evidence. According to Whewell, this rationalistic conclusion necessarily follows from the fact that we do find universal and necessary truths in science, that their universality and necessity cannot be grounded in experience, and that empirical data cannot provide the principles of intelligible connection which are found in the sciences.

Whewell described the process of discovery as involving first the Colligation of Facts. By the Colligation of the Facts, he meant the binding together of the facts into a connected whole through the introduction of an appropriate Idea or conception. This process cannot occur, however, until the facts have been accurately observed. Whewell regarded as a necessary preliminary step, the careful and precise observation of the facts

and sometimes also the carrying out of experiments as a means to providing desired data. Tycho Brahe's carefully collected observations were indispensable in providing material for Kepler's discovery of the orbit of Mars; but this mere collection of data was only preparatory to the essential step in discovery. That step is always marked by the introduction of a relating Idea, in the light of which the observed facts no longer appear as disconnected, but are brought into a coherent system of interrelations. To this step, Whewell applied the term, "the Colligation of the Facts."

"Facts such as the last Chapter speaks of are, by means of such Conceptions as are described in the preceding Chapter, bound together so as to give rise to those general Propositions of which Science consists. Thus the Facts that the planets revolve about the sun in certain periodic times and at certain distances, are included and connected in Kepler's Law, by means of such Conceptions as the *squares of numbers,* the *cubes of distances,* and the existing proportionality of these quantities. Again the existence of this proportion in the motions of any two planets, forms a set of Facts which may all be combined by means of the Conception of a *certain accelerating force,* as was proved by Newton. The whole of our physical knowledge consists in the establishment of such propositions; and in all such cases, Facts are bound together by the aid of suitable Conceptions. This part of the formation of our knowledge I have called the *Colligation of Facts:* and we may apply this term to every case in which, by an act of the intellect, we establish a precise connexion among the phenomena which are presented to our senses. The knowledge of such connexions, accumulated and systematized, is Science. . . ." (NOR. 59.)

The passage quoted above not only defines the meaning of the phrase the "Colligation of Facts;" it also illustrates the doctrine of the Fundamental Antithesis, and indicates Whewell's appreciation of the progressive development of science. The "facts" which Whewell cited as bound together by the discoveries of Kepler and of Newton, are not crude sensory data. They are observations which could be made only after the development of scientific theory had made possible the construction of accurate instruments for observation and had provided formulae for calculating the positions of the planets at times of observation on the basis of the observed data. "The Facts that the planets revolve about the sun in certain periodic times and at certain distances" are not "facts" for everybody to see, but can be recognized as

" facts " only by those who comprehend the theoretical principles which have been involved in the establishment of these " facts." In some sense, it is the same point that is illustrated by the citation of Newton's discovery as involving Kepler's previous discovery. As Whewell stated elsewhere, Kepler's " theory " became " fact " for Newton and provided material which Newton colligated by introducing the conception of universal gravitation. (NOR, 116.) Thus science progresses by the introduction of Ideas and Concepts which at first appear to bind the facts together, but which are absorbed into the " facts " and are looked upon by succeeding discoverers as part of the given data.

In the Colligation of the Facts, the new Idea or Conception is suggested in the light of which the facts are seen to be intelligibly related. This step in discovery is the work of a single individual. He grasps the right Idea by some process which is beyond the reach of method, and then attempts to impart it to others. Whewell showed that many individuals contribute to the collection and organization of facts which are first clearly understood when some inventive genius discovers the Idea by which they can be colligated. Again, many contribute to the verification of the new discovery, frequently suggesting necessary modifications. Although the actual discoverer is a single individual, the significance of his work is greatly increased by the contributions which others make in whipping his notions into such shape that they can be recognized generally as true and sufficient explanations of the facts.

Whewell usually emphasized the contribution of the individual in the history of scientific development, but he also appreciated the fact that discoveries made by individuals are of no more than antiquarian interest if they are not adopted into the current scientific thought. Whewell called attention to the fact that discoveries may be quite lost to posterity if they are not brought into connection with other facts through some attempt at explanation. More than once, Whewell cited the alleged discovery of the moon's variation by Aboul Wefa, in the middle ages, as an example of a discovery which had been forgotten simply because current theory could not take account of it. The claim that Aboul Wefa had anticipated Tycho Brahe's discovery has now been discredited, and it was criticized even in Whewell's time, so that this illustration should have been replaced by another, and very likely would have

been replaced if Whewell had ever made any attempt adequately to revise his work after the publication of the first edition. Better accredited illustrations might be found now; for instance, the fact that Mendel's work, an account of which was published in 1865, attracted little attention until the development of theory had so prepared men to comprehend the significance of Mendel's findings that in 1900 three independent investigators rediscovered his reports. Whewell's observation was correct, even though his own illustration must be rejected.

The mere preservation of discoveries is not the only contribution made by the less outstanding scientists. They play an indispensable part in the Explication of Conceptions, which Whewell regarded as the necessary supplement to the Colligation of the Facts in the process of discovery. Under "Explication of Conceptions," Whewell included the development of the conceptions, the clear expression of the implications of the Fundamental Ideas from which they are derived, and the formulation of definitions of the conceptions.

Whewell discussed the process of the Explication of Conceptions before he discussed the Colligation of Facts. This seems like an arbitrary inversion of the actual course of discovery, for the Explication of Conceptions is necessarily subsequent to the discovery of the Fundamental Ideas from which the conceptions are derived. Perhaps Whewell selected this order of discussion because he wished to stress the fact that clear comprehension of Ideas previously discovered, and of their precise determinations in application to particular material, is a necessary preliminary to further progress. Newton never could have discovered the theory of universal gravitation if he had not previously grasped the full implications of Kepler's work. Kepler's discovery was dependent upon his familiarity with the Copernican view, as well as upon his knowledge of mathematics and his use of Tycho Brahe's observations. The implications of earlier discoveries must be fully developed (at least in so far as they can be developed independently of later discoveries) before new discoveries are in order, for these last are dependent upon them.[1] Whewell's

[1] Both Whewell and Comte appeared to assume that the progress of science follows persistently a single direction. They failed to appreciate the fact that progress in the more complex, and later developed sciences may contribute to progress in sciences whose first advances have been made much earlier.

view seemed to be that clear and certain gains must be made in each science in a perfectly orderly fashion, and that the implications of one discovery must be explicit and precise before other discoveries are possible.

In the case of any particular discovery, however, the Explication of Conceptions follows the discovery of the colligating Idea. The first steps in explication are usually made by the first discoverer of the Idea. In order to express his notion with intelligible precision, the discoverer proceeds to show in just what form the Idea is applicable to the particular facts with which he is concerned. This frequently involves the establishment of a law and the simultaneous establishment of a definition. Whewell showed that the establishment of the definition is often the concluding step in an induction. He made no claim that this was an original observation, for he was pleased to note that in the middle ages writers on logic had observed this fact. (NOR, 40.) Whewell showed that the history of science confirms this observation, and he explained why definitions must come at the end in a process of induction.

The introduction of the appropriate Idea determines the point of view from which the phenomena must be considered, but it does not provide for the precise determinations of the relations which it reveals. Only the objectively determined data can provide material for formulating the precise laws and definitions which are characteristic of science. Whewell protested against the notion that definitions might be arbitrarily established, and he proposed the contrary view that definitions are not essential to the Explication of Conceptions but are merely convenient for the clear and concise formulation of propositions. The successful investigator must be free from confusion concerning his conceptions, but he does not necessarily express his notion in a formal definition. An analysis of the laws which are discovered reveals the conceptions which are implicit in them, and which may then be set forth explicitly in the form of definitions.

The establishment of definitions frequently follows a period of scientific controversy and discussion. Often the discoverer first propounds his views in a form which is not clear to all who are interested in the solution of the problem. Critics call attention to apparent inconsistencies in the proposed theory. In answer to such criticism, the defenders of the new view must either show

more clearly how the theory is self-consistent and is in agreement with the facts, or they must modify the view as first proposed until it does satisfy such fundamental demands.

Whewell observed that scientific controversies often seem to be concerned only with definitions, but he remarked that even in such cases the question is not really one about definitions but about the general propositions in which the terms are employed. The importance of disputes about definitions is that "they dissipate all ambiguity and vagueness in the use of terms, and bring into view the conditions under which the fundamental principles of our knowledge can be most clearly and simply presented." (HSI, I, 261.) The point at issue is not the establishment of particular definitions so much as the justification of general points of view, but only through the definitions can the new conceptions be made perfectly clear, and the meanings of asserted propositions be generally agreed upon.

Whewell fully appreciated the importance of controversies in the history of science. He realized that it is through the discussion and criticism which controversies involve that the Idea, first appreciated by the discoverer alone, is made comprehensible to an increasingly wide circle until it finally becomes the intellectual property of all who are capable of intelligently considering the problem. Whewell showed his keen appreciation of the progress of thought by scoffing at those whose lack of historical perspective causes them "to talk with contempt of all past controversies, and to wonder at the blindness of those who did not *at first* take the view which was established at last." "Such persons," Whewell continued, "forget that it was precisely the controversy, which established among speculative men that final doctrine which they themselves have quietly accepted. . . . To despise those who have, by their mental struggles and conflicts, brought the subject into a condition in which errour is almost out of our reach, is to be ungrateful exactly in proportion to the amount of benefit received." (NOR, 183.) Whewell regarded the discussion which follows the promulgation of a new theory as a part of the process of discovery, for it is through such discussion that the conceptions attain the clarity which makes their eventual general acceptance inevitable.

This discussion of new conceptions is usually attended by the introduction of new terms, designed to convey the new and precise

meanings which the conceptions attain as the result of the process of explication. Whewell was much interested in the language of science, and devoted the fourth book of the *Novum Organon Renovatum* to considerations of that subject. In earlier editions of the *Philosophy of the Inductive Sciences,* Whewell had given some ninety pages to this subject, but in the *Novum Organon Renovatum,* he introduced additional material, in which he made more clear the philosophical implications of the development of scientific language.

In his first aphorisms, Whewell had laid down maxims for the convenient formation of new technical terms and new systems of nomenclature. He offered some judicious precepts as a guide in the formation of systems of nomenclature, referring appreciatively to the Linnaean system in botany, and making suggestions which he hoped would be followed in the development of mineralogy and chemistry. However, he was particularly interested in the formation of new technical terms. He desired that terms should conform to philological rules, but he was not dogmatic on this point, conceding that terms which were becoming familiar should not be changed merely because they were formally faulty. The principles governing Whewell's announcement of aphorisms concerning the language of science were so moderate and sensible as to merit general approval. Whewell's directing principle seemed to be his recognition that the function of scientific terms is to convey precise meanings briefly and conveniently. He maintained that such terms cannot be used with the freedom of everyday notions, but he did not object to the appropriation of familiar terms if confusion with their original, loose meaning could be avoided. He advised the selection of terms which are of flexible form, so that nouns, adjectives, verbs, and adverbs may be conveniently derived from a single stem.

Whewell was also interested in the mnemonic values of terms. He made some interesting observations concerning the greater ease with which we adopt terms whose derivations suggest their significance without implying too definite theory. Without mentioning the fact that he himself was responsible for suggesting to Faraday the terms "anode" and "cathode," Whewell cited these terms as exemplifying some of the precepts which he proposed. The terms are not perfectly arbitrary, but "they refer to a natural standard of the direction of the voltaic current, in a manner

which, though perhaps not obvious at first sight, is easily understood and retained." (NOR, 313.) It is apparent that Whewell appreciated the value of clues to meaning while he emphasized the necessity of avoiding implications of theories which subsequent scientific progress might show to be erroneous.

The merit of Whewell's suggestions is indicated not only in the fact that many scientists requested and followed his advice in the formation of terms which are now generally familiar,[2] but also in the fact that less technical terms which Whewell suggested have now become part of everyman's vocabulary. "Scientist," "physicist," "conductivity," are some of his happier suggestions. Others, like "idiopt," have not been required in frequent use and have been practically forgotten although they too testify to Whewell's fertility in suggesting convenient modes of expression.

The significance of the development of language as part of the process of discovery in science is emphasized by its connection with Whewell's general theory. According to Whewell, discovery involves first the collection of data. To this numerous individuals may contribute. Then comes the intuition of the appropriate Idea by someone whose intellectual endowments and whose concentration on the problem peculiarly fit him to succeed in colligating the facts by "superinducing upon them the appropriate conception." (NOR, 74, 101.) The successful discoverer can impart his idea to others only through the medium of language. Frequently his idea is misunderstood, and only through discussion and controversy can the new notion be made intelligible to all who are prepared to understand it. The new conception frequently requires to be expressed in new words, for familiar terms are not suited to convey new meanings briefly and clearly. In fact, Whewell maintained that the elaboration of a new and convenient terminology is almost a necessary condition of the general dissemination of new ideas. He compared the new terminology to a currency which facilitates exchange, and which permits the transmission of truths from individual to individual, and from group to group. (NOR, 276.) Whewell fully appreciated the importance of language as contributing to the general acceptance of new discoveries, and he expressed his consciousness of this value in terms which indicate his further recognition of the fact that the full significance of any discovery is achieved only when it has become a familiar part of

[2] Cf. IT, II, 109 ff., 178 ff.

the treasure of knowledge in which all men, as members of society, are enabled to share through their possession of common language and of common concepts.

". . . But what we have here to remark is, the extraordinary degree in which the progress of science is facilitated, by thus investing each new discovery with a compendious and steady form of expression. These terms soon become part of the current language of all who take an interest in speculation. However strange they may sound at first, they soon grow familiar in our ears, and are used without any effort, or any recollection of the difficulty they once involved. They become as common as the phrases which express our most frequent feelings and interests, while yet they have incomparably more precision than belongs to any terms which express feelings; and they carry with them, in their import, the results of deep and laborious trains of research. They convey the mental treasures of one period to the generations that follow; and laden with this, their precious freight, they sail safely across the gulfs of time in which empires have suffered shipwreck and the languages of common life have sunk into oblivion. We have still in constant circulation among us the terms which belong to the geometry, the astronomy, the zoology, the medicine of the Greeks, and the algebra and chemistry of the Arabians. And we can in an instant, by means of a few words, call to our own recollection or convey to the apprehension of another person, phenomena and relations of phenomena in optics, mineralogy, chemistry, which are so complex and abstruse, that it might seem to require the utmost subtlety of the human mind to grasp them, even if that were made the sole object of its efforts. By this remarkable effect of Technical Language, we have the results of all the labours of past times not only always accessible, but so prepared that we may (provided we are careful in the use of our instrument) employ what is really useful and efficacious for the purpose of further success, without being in any way impeded or perplexed by the length and weight of the chain of past connexions which we drag along with us." (HSI, I, 55.)

This recognition of the social importance of discoveries and of the manner in which they are disseminated so as to influence all future discussion, is an important aspect of Whewell's view of the process of discovery even though it is one to which he gave only incidental attention. Whewell was mainly concerned to emphasize the fact that there can be no discovery without intuition of a new Idea or Conception. He grouped his other observations about this central contention, and left for others the task of show-

ing more clearly how individual contributions to the progress of knowledge become part of the social heritage.

What happens when a new law of nature is discovered? Whewell described the event in this fashion: "A number of facts in which, before, order and connection did not appear at all, are brought into a point of view in which order and connection become their essential characters." (BT, III, iv.) Whewell emphasized this relating character of induction with the help of similes. A favorite of his, and one which has been frequently repeated, is his suggestion that the discovered conception may be likened to the thread upon which are strung the separate pearls of facts.

"The facts are known, but they are insulated and unconnected, till the discoverer supplies from his own stores a Principle of Connexion. The pearls are there, but they will not hang together till someone provides the String. The distances and periods of the planets were all so many separate facts; by Kepler's Third Law they are connected into a single truth: but the Conceptions which this law involves were supplied by Kepler's mind, and without these, the facts were of no avail. The planets described ellipses around the sun, in the contemplation of others as well as of Newton; but Newton conceived the deflection from the tangent in these elliptical motions in a new light,—as the effect of a Central Force following a certain law; and then it was, that such a force was discovered truly to exist." (NOR, 73.)

The figure of the stringing of the pearls emphasized the introduction of the Idea or Conception as a connecting principle, giving order and coherence to the previously separate facts. The mind contributes these relating notions, and so makes an intelligible whole out of an incoherent mass of facts. However, Whewell did not maintain that the mental contribution in discovery consists merely in the introduction of a bond of connection; he insisted that interpretation of the data is involved in the discovery of the successfully relating Idea. Perhaps a more fruitful analogy than the one of the stringing of the pearls, is that of the reading of a manuscript written in unknown characters. This comparison was not original with Whewell, for at least Bacon and Leibnitz had employed the notion earlier. Whewell proposed the analogy in discussing the aphorism which he took over from Bacon: "Man is the Interpreter of Nature," and to which he added the phrase, "Science is the right Interpretation." (HSI, I, 42.) Whewell spoke of nature as a book which we must learn to read by dis-

covering the alphabet of appropriate Ideas. He contended that prediction of future events may be valid evidence of correct reading, and that agreement between inductions, like agreement between translations of different manuscripts, must be acknowledged to be a striking indication of correct interpretation. In the discussion of the process of discovery, the significance of the analogy lies in the fact that it emphasizes the intelligibility which is introduced into our perception of the universe by the discovery of the relating Idea. Meaning appears where there was no meaning before. What seemed to be a fortuitous concurrence of events, now appears to be an articulated whole, with each part having its meaning in relation to all the rest. Science makes nature appear to be an intelligible totality instead of the succession of more or less independent events which it may at first appear to be.

"Nature is the Book, and Man is the *Interpreter*. The facts of the external world are marks, in which man discovers a meaning, and so reads them. Man is the Interpreter of Nature, and Science is the right Interpretation. And this image also is, in many respects, instructive. It exhibits to us the necessity of both elements;—the marks which man has to look at, and the knowledge of the alphabet and language which he must possess and apply before he can find any meaning in what he sees. Moreover this image presents to us as an ideal element, an activity of the mind of that very kind which we wish to point out. Indeed the illustration is rather an example than a comparison of the composition of our knowledge. The letters and symbols which are presented to the Interpreter are really objects of sensation: the notion of letters as signs of words, the notion of connexions among words by which they have meaning, really are among our Ideas;—*Signs* and *Meaning* are Ideas, supplied by the mind, and added to all that sensation can disclose in any collection of visible marks. The Sciences are not figuratively, but really, Interpretations of Nature. But this image, whether taken as example or comparison, may serve to show both the opposite character of the two elements of knowledge, and their necessary combination, in order that there may be Knowledge." (HSI, I, 140.)

In this emphasis upon the interpretative aspect of science, Whewell stood apart from his English contemporaries, as represented by Herschel and John Stuart Mill, for instance. In general, they admitted Whewell's contention that the essence of discovery consists in the relating of facts whose inter-connections had not been recognized previously. But they opposed Whewell's

rationalistic contention that the connecting bonds are introduced from the mind, where they are found as *a priori* Ideas. Most British thinkers tended toward the realistic position that the relations are to be discovered in nature, just as the sensory data are. They denied Whewell's epistemological premise that the universality and necessity of the laws of nature must have some other ground than experience, and in contradiction to his view that relations cannot have their source in sensation (HSI, I, 31), the empiricists maintained that relations are, in fact, objectively determined items of experience.

Herschel and Whewell spoke very highly of one another's work and each realized that the other had contributed to the understanding of the problems of induction; but they were by no means in full agreement. Herschel indicated the fundamental difference in their views when he said that there are two schools in the philosophy of science: first, that which refers all our knowledge to *experience,* reserving to the mind only a high degree of activity in collecting data, and, second, that which assumes the presence of *innate conceptions* and truths antecedent to experience. He himself was confessedly of the former school, Herschel said, while Whewell he credited with pressing the doctrines of the latter school farther than any except, perhaps, the Germans.[3] This statement represented the attitude which was generally taken towards Whewell's theories: he was regarded as the great defender of apriorism, and little importance was attached to his emphatic assertions that facts are the *a quo* and *ad quem* of science, though not its sole and sufficient source.[4]

Herschel recognized the part played by the active mind in the formation of science. In his *Discourse on the Study of Natural Philosophy,* Herschel used descriptive phrases which might have been borrowed by Whewell, for he spoke of "obscurities . . . dispelled, . . . as if by inspiration into rich and inexhaustible springs of knowledge and power, on a simple change of our point of view,

[3] *Quarterly Review,* June, 1841. Vol. 68, pp. 96–130, American Edition. Cf. p. 99.

[4] Contemporary criticisms may be found in the following: G. H. Lewes, *Biographical History of Philosophy,* first edition; H. L. Mansel, *Prolegomena Logica;* Robert Blakey, *History of the Philosophy of Mind,* Vol. iv; Leslie Stephen, *The English Utilitarians,* Vol. iii; John Grote, *Exploratio Philosophica;* as well as in reviews listed in the bibliography appended to this essay.

or by merely bringing to bear on them some principle which it never occurred before to try. . . ." [5] However, Herschel followed the Scotch, rather than the Germans, in postulating an "inductive propensity—the irresistible impulse of the mind to generalize *ad infinitum*" [6] as an explanation of the general conviction of the universality of scientific laws. Herschel held that the mind supplies nothing but completion of continuity through force of habit.[7] He steadfastly refused to assent to Whewell's aprioristic doctrines even though he recognized the relating activity of mind. The essential difference in their views is this: whereas Whewell implied that the mind contributes to sensory data its form, and to science the Ideas which assure the universality and necessity of scientific laws, Herschel spoke of the mind's activity in induction as if the mind organized data but never added to it. The contrast is made clear in Herschel's review of Whewell's position, for obviously Whewell could not accept the interpretation of his views which that suggested:

"Mr. Whewell observes that 'the familiar act of thought exercised for the common purposes of life, by which we give to an assemblage of our impressions such a unity as implied in the above notions and terms *a month, a year,* and the like, is in reality an *inductive* act, and shares the nature of the processes by which all sciences are formed.' Hist., b. I, p. 109.

"If the term *inductive,* applied here to this very important mental act, be understood in that technical sense in which it is commonly used when speaking of physical discoveries, viz. as the concluding of something more general by the assemblage of particulars of a less general kind, we must demur to this remark; but if it be intended to designate every inductive act of the mind as an instance of the exercise by it of that peculiar constructive or plastic faculty in virtue of which out of the assembled perception of qualities it constitutes an object—out of extension, figure, resistance, colour, smell, a body—out of a series of dots an outline, &c.—then we not only agree with the assertion, but regard it as expressing a full and complete theory of induction itself, and of the mode in which our minds not only form to themselves conceptions of numerical aggregates by the contemplation of units, but *construct general propositions themselves from the contemplation of particulars, and attribute to them a universality which experience alone is incapable of warranting.*[8]

[5] *Op. cit.,* Philadelphia, 1840, p. 6.

[6] *Quarterly Review,* June, 1841. Vol. 68, p. 119, American Edition.

[7] *Ibid.,* p. 105.

[8] *Ibid.,* p. 105.

In this review of Whewell's *History* and *Philosophy,* Herschel made a friendly gesture of conciliation, suggesting that after all, the differences between Whewell's views and his own were not essential. This conciliatory suggestion really represented only a blurring of differences which have separated rationalists from empiricists in the whole history of thought. Herschel belonged to the group of the realists and empiricists. He knew that his friend Whewell had also a hearty respect for the empirical method in science, and that he asserted a belief in the agreement of the actual course of nature with its right interpretation in science; consequently, Herschel was inclined to forgive Whewell his differences from the empiricistic thinkers. The gesture with which Herschel announced this, however, necessarily represented a disregard for the apriorism which was essential to Whewell's philosophy. Herschel's resolution of the differences between him and Whewell rested only on an appeal to the ultimate bases of all philosophies; there realist and idealist, rationalist and empiricist can be made to appear at one only because appeal is to the principles from which they all set out on their various ways of explanation: science represents knowledge of an objective universe, "objective" in either the realist's or the idealist's sense of that term, and the origin of science must be explained by showing how knowing selves can attain knowledge of this common universe. Herschel's suggestion that the different ways of explanation are only apparently opposed really represents merely a restatement of the fundamental problem together with the implication that the problem is insoluble.

"And after all, it seems far from certain that this opposition of views is anything more than apparent; for among the infinite analogies which may exist among natural things, it may very well be admitted that those only are designed, in the original constitution of our minds, to strike us with permanent force, to embody around them the greatest masses of thought and interest, to become elaborated into general propositions, and finally to work their way to universal reception, and attain to all the recognizable characters of truth, which are really dependent on the intimate nature of things as that nature is known to their Creator, and which have relation to their essential qualities and conditions as impressed on them by Him; so that the power bestowed on the mind of seizing on those primordial analogies, and its impulse to generalize the propositions which their consideration suggests, on the one view of the subject —are equivalent to its endowment with a direct recognition of

fundamental ideas and relations not derived from experience, and the evolution from those ideas of necessary truths equally independent of experience, in the other. And, perhaps, with this explanation both parties ought to rest content—satisfied that, on either view of the subject, the mind of man is represented as in harmony with universal nature: that we are consequently capable of attaining to real knowledge; and that the design and intelligence which we trace throughout creation is no visionary conception, but a truth as certain as the existence of that creation itself." [9]

Whewell was not content with such a dismissal of essential differences. His more detailed discussion of the process of discovery showed how he differed from contemporary British empiricists, and also how he separated from the German post-Kantians with their absolute idealisms. His description of the steps involved in discovery presented generalizations based upon his review of the historical developments of the various inductive sciences. He drew his conclusions concerning the process of discovery not only from a philosophical analysis of discoveries in general, but also from an examination of various scientists' accounts of their own discoveries. This latter method provided material for a psychological account of induction; the former provided only for an epistemological analysis. Even Whewell's opponents acknowledged that he had aptly described the process of arriving at scientific generalizations, although they rejected his interpretation of that description in terms of his aprioristic philosophy.[10]

Whewell emphatically opposed the empiricists' attempt to show that induction is merely a case of comparison and abstraction, possibly differentiated from the most common cases by the more extensive application of the resulting concept and by the functioning of an "irresistible impulse to generalize *ad infinitum*," such as Herschel posited. Whewell took the position that the discovery of a new law of nature involves a process that differs from ordinary experience in depending upon the intuiting of an *a priori* Idea, which is not given in experience, but is discovered in the mind and is recognized as necessary to bring the various elements of experience into connection with one another. Whewell appreciated the fact that the new point of view comes to be generally accepted so that finally the connections are no longer regarded as

[9] *Ibid.*, p. 99.

[10] Cf. J. S. Mill, *System of Logic*, Book III, chapter iii, section 4.

additions to the original data. This observation caused him to consider his opponents' contention that the connections are really given in the facts as the consequence of an insufficient analysis. Whewell was quite aware that when the relating conception has become familiar, it appears, not as an addition to the facts, but as an abstraction from the facts, as Mill regarded it. However, Whewell maintained that the process is actually the reverse of what Mill described it to be. Whewell insisted that the apprehension of the conception as part of the facts is a *consequence of familiarity with the Idea* and is necessarily subsequent to the discovery of the Idea and its application to the facts. Whewell's epistemological presuppositions were not the only evidence supporting the adoption of such a point of view. Whewell seemed, at least to himself, to find conclusive evidence for this theory in his observation that only those who have been made familiar with the relating conception do in fact find it given as part of the facts.

Whewell contended that discovery comes as the fortunate intuition of the appropriate Idea by which the facts can be connected. His essential difference from those who, like Bacon, wished to find an *art* of discovery, lay in Whewell's conviction that the necessary relating conception can never be found in the facts, but must be contributed to the facts *ab extra,* from the mind. Although Whewell discussed various "methods employed in the formation of science," he regarded these simply as useful tools of research. (NOR, 141.) His discussion of the Method of Curves, the Method of Means, the Method of Least Squares, and the Method of Residues, to which he devoted a chapter headed "Methods of Induction," shows a due appreciation of these methods, of which he had made masterly use in preparing his memoirs on the tides.[11] Whewell also recognized the limitations of these methods. They may reveal more clearly facts which require explanation, but they cannot supply the explanations. These require the introduction of conceptions from the mind. Whewell considered the "Method of Gradation" and the "Method of Natural Classification" as applicable to material in which qualitative, as distinguished from quantitative, considerations are significant. It seems evident, however, that these last "methods" are better considered as implying points of view, for they are not susceptible of application in the same definite fashion as the others. Moreover, they are not so

[11] Cf. page 11 ff., above.

widely applicable as Whewell seemed to believe. His conviction that the correct definition of the concept of "species" as applicable in mineralogy (for he took it for granted that it is applicable), was the next step necessary to further progress in that field (NOR, 45), shows his tendency to extend the "Method of Natural Classification" to non-biological material, where the thought of its application seems ludicrous to a modern reader.

Whewell realized that the most fruitful employment of methodological tools cannot be determined in advance. Successful scientific investigation depends always upon some insight which is beyond reach of method, although methodological aids may be employed in preliminary investigation. Whewell even denied that a detailed program for future research can legitimately be derived from a study of past progress, for he realized that each discovery suggests new problems and indicates new modes of attack. He finally chose to content himself with analyzing past discoveries, rather than offering precepts for future investigation.

Although Whewell recognized the inadequacies of such methods as Bacon proposed, his concern with empirical matters made Whewell equally unable to adopt Descartes' rationalistic faith in his deductive method, for Whewell started from the point of view that fundamental scientific principles are *a priori* and are not derivable from any previously accepted definitions or axioms. In contrast to those who put their faith in method, Whewell made a miracle, or at least an insoluble mystery, of the intuition of the successful Idea, repeatedly emphasizing the point that it is given only to genius to make such happy discoveries.

> "Scientific discovery must ever depend upon some happy thought, of which we cannot trace the origin;—some fortunate cast of intellect, rising above all rules. No maxims can be given which inevitably lead to discovery. No precepts will elevate a man of ordinary endowments to the level of a man of genius: nor will an inquirer of truly inventive mind need to come to the teacher of inductive philosophy to learn how to exercise the faculties which nature has given him." (NOR, 44.)

Whewell seemed inclined to regard the problem of discovery as one which might be settled only by showing what *must* be involved in accordance with the conclusions of his epistemological analysis. The psychological problem of *how* the mind may be led to intuit the relating Idea, and what the fact of discovery may imply as to

the nature of mental processes, was not one with which Whewell cared to concern himself. Nevertheless, Whewell did make some suggestive psychological observations concerning the process of discovery, for he wanted to refute the notion that discoveries might be accidental, as well as to discourage the hope fostered by Bacon that a method might be found which would "enable all men to construct Scientific Truths, as a pair of compasses enables all men to construct exact circles." (NOR, v.)

In criticizing the common view that great discoveries can be explained by some fortuitous occurrence, Whewell asserted that the occurrence was of consequence only because it befell an individual who was prepared to see in the event something which it would not suggest to others. An individual's innate intellectual equipment, his interests, education, and awareness of problems are all essential factors contributing to his success in scientific discovery, according to Whewell. Whewell's view that discovery consists in the colligating of facts by applying to them the right conceptions, accounts for his emphasis on the importance of subjective factors, for the denial that these conceptions are derived from objectively determined elements of experience is a cardinal point in his philosophy.

"*No scientific discovery* can, with any justice, be considered *due to accident.* In whatever manner facts may be presented to the notice of a discoverer, they can never become the materials of exact knowledge, except they find his mind already prepared with precise and suitable conceptions by which they may be analysed and connected. . . . When the observer's mind is prepared with such instruments, a very few facts, or it may be a single one, may bring the process of discovery into action. But in such cases, this previous condition of the intellect, and not the single fact, is really the main and peculiar cause of the success." (NOR, 46.)

Whewell did not insist that all the conceptions which are employed in successful colligation must be *a priori* in the mind of the observer. Kepler's discovery of the elliptical paths of the planets was recognized as a classic instance of the successful application to new material of a conception acquired in past experience. Whewell merely wished to emphasize the fact that the subjective conditions, which he classed together as "habits and constitution of intellect," are the determining factors in discovery. Externally determined events merely serve as occasions to stimulate activity

and perhaps to suggest new aspects of the data. Whewell resented the common explanation that Newton's discovery was a consequence of an apple's falling on his head. Whewell attempted to refute that notion in a terse statement:

"If it were true that the fall of an apple was the occasion of Newton's pursuing the train of thought which led to the doctrine of universal gravitation, the habits and constitution of Newton's intellect, and not the apple, were the real source of this great event in the progress of knowledge." (NOR, 47.)

In his discussion of particular discoveries, Whewell noted that frequently habits of persistent attention to given problems have prepared discoverers to find solutions even in apparently irrelevant events. Newton explained his success neither by the apple nor by a chance hitting upon the right idea. Whewell adopted the discoverer's own view that his triumph was due to his constant attention to his problem.

"When he was asked how he made his discoveries, he answered, 'by always thinking about them;' and at another time he declared that if he had done anything it was due to nothing but industry and patient thought: 'I keep the subject of my industry constantly before me, and wait till the first dawning opens gradually, by little and little, into a full and clear light.'" (HIS, II, 140.)

These observations of Whewell's sound commonplace now, but when they were written, before the Külpe school had emphasized the importance of attitude in perception and action, and while associationism was the reigning psychology in England, these observations presented original and rather heterodox views. It is clear that Whewell could not accept the current associationism as a satisfactory explanation of the psychological aspects of discovery. He insisted that relations are not given as part of experience, and he also declared that the attitude and interests of the observer are significant factors in determining what associations will be suggested by any experience. But Whewell failed to develop these constructive suggestions; he, as well as his readers, forgot them in considering the epistemological problems suggested by his doctrines of the Fundamental Antithesis and the *a priori* character of the Fundamental Ideas.

Although Whewell described the process of discovery as involving the intuition of the appropriate Idea and the formation of the correct Conception, he sometimes spoke in terms that suggest to

the reader of today that he thought of discovery as involving a sort of trial and error process. The investigator must gather together the facts which he would explain, and then he must seek for the Idea or Conception through which the facts can be brought into intelligible connection with one another. Kepler's account of his own persistent and laborious efforts to discover the path of Mars showed how many unsuccessful guesses he had followed through before hitting upon the right one. Whewell remarked that this experience is probably repeated more frequently than the usual brief accounts of the finding and verifying of correct hypothesis would lead one to suspect. (NOR, 82.)

The successful Colligation of the Facts depends neither upon accident nor upon the diligent prosecution of a method of discovery. It involves an intuition of the relating Idea which usually comes only after other Ideas have been suggested. Whewell realized that the correct notion is not usually hit upon at once, and he included fertility in forming hypotheses among the indispensable characteristics of the successful scientist. Attempts to verify wrong hypotheses may suggest the right ones, Whewell pointed out. Moreover, a willingness to risk *some* guesses is obviously a necessary condition of hitting upon *right* ones. (NOR, 78 ff.)

This necessary guessing is more formally designated " formulating hypotheses." Hypotheses are essentially guesses at the way phenomena are related. Legitimate hypotheses take account of all the known facts and are subjected to test before being accepted. Moreover, the hypotheses must be rejected at once, or at least modified, if attempts to prove them show that they are not correct or are insufficient. Whewell repeatedly referred to the necessity of an investigator's relinquishing even a favorite idea when it seemed not to be in harmony with the facts. (NOR, 80.)

It was something merely to insist upon the indispensable part played by hypotheses when Newton's "*Hypotheses non fingo,*" seemed to discourage their employment. Whewell insisted, in contradiction to current interpretation, that Newton had employed hypotheses in their legitimate sense, and meant only that he did not make wild guesses, unsupported by sufficient evidence. Whewell interpreted Newton's assertion that his success depended upon his constant consideration of his problem as meaning that he persistently tried, at least implicitly, all of the plausible sug-

gestions that occurred to him, until at last he hit upon the correct one.

"It is related that when Newton was asked how it was that he saw into the laws of nature so much further than other men, he replied, that if it were so, it resulted from his keeping his thoughts steadily occupied upon the subject which was to be thus penetrated. But what is this occupation of thoughts, if it be not the process of keeping the phenomena clearly in view, and trying, one after another, all the plausible hypotheses which seem likely to connect them, till at last the true law is discovered? Hypotheses so used are a necessary element of discovery." (PD, 183.)

Whewell concluded that Newton's objection was rooted in "a horror of the term *hypothesis,* which probably arose from his acquaintance with the rash and illicit general assumptions of Descartes." Whewell was quite certain that Newton meant to condemn only the "Anticipations of Nature" to which Bacon also had wisely objected. From Whewell's point of view, a refusal to try hypotheses would be equivalent to a refusal to contribute to the progress of science. Whewell regarded the formation of hypotheses as attempts to colligate the facts by introduction of relating Ideas. The discovery of the *right* Idea can occur only when the investigator is actively seeking some means of colligating the facts, that is, when he is trying to formulate satisfactory hypotheses.

Whewell's emphasis on the importance of hypotheses was not properly appreciated in his own day. Lalande deplores the indifference to Whewell, and suggests that the difficulty of his name may have been partly responsible for his neglect in France.[12] He also suggests the better explanation that the empirical tendencies of immediately subsequent thought in England were fundamentally opposed to Whewell's rationalism, and caused it to be quickly forgotten. Whewell deserves to be remembered especially as a staunch defender of hypotheses. He criticized Newton's "Rules of Philosophizing" on the double ground that they were obviously formulated to justify Newton's own procedure in his discovery of universal gravitation and that they suggest a misapprehension of the nature and function of hypotheses in general. Whewell undertook to show that Newton's famous induction actually involved the formulation and verification of an

[12] *Revue des Cours et Conférences,* July, 1923. Vol. 24, Part II, page 1395, note.

hypothesis, although Newton had suggested a contrary view by the mode of expression which he used in criticizing the hasty elaboration and acceptance of ill-founded and unverifiable hypotheses. Whewell found in Comte a more recent opponent of hypotheses. Whewell answered Comte by asserting that the past history of science shows the necessity of hypotheses such as Comte condemned. Whewell pointed out also that the "facts" of present day science involve a large element of what Comte condemned as "metaphysics." (NOR, 126.) The so-called "facts" are really interpretations made in the light of hypotheses which have now become so familiar and are so unquestioningly accepted that only a searching analysis reveals them in the facts.

In his view of the importance of hypotheses, Whewell was in sympathy with many thinkers whose names are familiar in the history of science, and also with those who have recently contributed to the philosophy of science. Lalande lists an imposing array of the defenders of hypotheses: Hooke, Huyghens, D. Bernoulli, Bonnet, Lesage, Hartley, Boscowich, Dugald Stewart, and others, but he speaks of Whewell especially as "le représentant le plus remarquable de l'école 'hypothétiste' (si l'on peut ainsi parler), dans la première moitié du xix^{e} siècle." [13] Another, also mentioned by Lalande, was Sir John Herschel, whose opinions were always of interest to Whewell, and with whom Whewell had discussed some of their common problems while they were undergraduates at Cambridge. The opposition between Herschel's empiricism and Whewell's rationalism has already been discussed.[14] In spite of the unbridgeable chasm which separated them in their fundamental points of view, Herschel and Whewell were agreed that the introduction of hypotheses is an essential step in induction. Both insisted that legitimate hypotheses must be in harmony with all known facts, and must be accepted only tentatively until subsequent observations or experiments require their rejection, or justify their retention and serve to promote their general acceptance.

Lalande shows an appreciation of Whewell's contribution which is probably enhanced by Whewell's recognition of problems which have given rise to Lalande's own theory of "*la raison consti-*

[13] *Ibid.*, pages 1387–1404.

[14] Cf. above, page 75 ff.

tuante" and *"la raison constituée."*[15] Lalande's views seem to involve as essential elements modifications of Whewell's theories of the Fundamental Antithesis and of the transformation of theories into facts. Intelligible order is introduced into experience in accordance with *"la raison constituante." "La raison constituée"* depends upon the combination of sensory and rational elements. It represents a product of past rationalization of data and serves as the foundation for all subsequent reasoning. Lalande's solution provides a more sophisticated interpretation of facts which Whewell must be credited with noting at a time when the general point of view was not well enough developed for his contemporaries to appreciate the significance of his observations. Whewell was very forward-looking in his recognition of problems, but his solutions were too often suggested by philosophical dogma and by religious prejudices. Whewell was not great enough to transcend the restrictions of traditional theories except when he was coerced by the facts. To them he submitted in the spirit of a keenly observant and sympathetic follower, who saw much that others failed to notice, but who could not satisfactorily explain all that it was given him to observe.

[15] *Revue des Cours et Conférences,* April 15 and 30, 1925. Vol. 26, Part II, pp. 1–12; 97–111.

CHAPTER V.

The Logic of Induction.

The problem of the logic of induction was revived for nineteenth century thought by the appearance of Herschel's *Preliminary Discourse on the Study of Natural Philosophy,* published in 1830. In this small volume, Herschel indicated a philosophy of science, discussed the principles underlying the development of the physical sciences, and briefly described methods which had proved fruitful in application. He also included short accounts of contemporary developments in particular sciences, commenting on their mutual relations. Whewell's *Philosophy of the Inductive Sciences,* which appeared a decade later, represented a more ambitious consideration of similar topics. These two books may be credited with introducing problems of inductive logic into nineteenth century thought, and also with reviving a general interest in philosophy at Cambridge.[1] John Stuart Mill acknowledged that without the inspiration of these two books his own discussion of inductive logic probably would not have been written.[2] Whewell was fully aware of the fact that Herschel and he had succeeded in arousing a new interest in these problems. When Mill's book appeared, Whewell could write to Herschel, "There is in new books of this kind a satisfaction in which both you and I may have a share. I mean that notions and expressions which were new and strange when we began to write, are now familiarly referred to as part of the uncontested truth of the matter." (IT, II, 315.)

Herschel and Whewell are not infrequently referred to merely as predecessors of Mill.[3] This is natural in view of the fact that Mill's book was enthusiastically received and widely read, so that his philosophy for a time dominated English thought. Moreover,

[1] Cf. Sidgwick, *Philosophy at Cambridge, Mind,* 1876; Vol. I, pp. 235–245.

[2] J. S. Mill, *System of Logic,* Preface to the first edition.

[3] Cf., for example, Liard, *Les Logicians anglais contemporains,* Paris, 1878. Also, Leuckfeld, *Zur logischen Lehre von Induction, Archiv für Geschichte der Philosophie,* 1898; Vol. 11, pp. 374–390.

Mill put the problem of induction in a new light. Herschel and Whewell had been concerned primarily with an analysis of the process by which discoveries actually have been made. Mill, whose interest was primarily in logic, took the point of view that all logic, even inductive logic, is concerned only with problems of proof. According to Mill, neither Herschel nor Whewell had really attempted to deal with the problems of inductive logic, properly so called. They had occupied themselves rather with problems of discovery.[4]

Nevertheless, Whewell had devoted a chapter in the *Philosophy of the Inductive Sciences* to discussion of "The Logic of Induction." (NOR, 97 ff.) In this chapter he presented the inductive tables which he proposed as analogous to the syllogism of deductive logic. The form of the inductive tables was designed to guarantee the validity of inductive conclusions just as the syllogistic form guarantees the validity of deductive conclusions.

"Such tabular arrangements of propositions as we have constructed may be considered as the *Criterion of Truth* for the doctrines which they include. They are the Criterion of Inductive Truth, in the same sense in which Syllogistic Demonstration is the Criterion of Necessary Truth,—of the certainty of conclusions, depending upon evident First Principles." (NOR, 115.)

This seems to indicate that Whewell recognized the need for formal methods of proof in induction, but an examination of the tables which he proposed shows that they do not in fact meet that need. The tables look very much like genealogical tables, and, as Whewell remarked, they really are genealogical tables of scientific generalizations. (NOR, 98.) The earliest known facts in the particular branch of science under consideration are bracketed together. Below the bracket is a statement of the proposition by which they were first successfully colligated. The name of the discoverer of the law, or in default of that, of the people among whom the law was first recognized, is also given. This proposition is in turn bracketed with others coördinate with it, and below the bracket is set forth the more general proposition in which they have been included. In accordance with Whewell's previously noted observation that "theories" become "facts" for future advances, earlier discovered laws are shown to be subsumed with others in wider generalizations, until the table stops when every-

[4] *Op. cit.*, Book III, chapter ix, section 6.

thing has been presented as included in the widest generalization yet obtained. As examples, Whewell inserted in the *Novum Organon Renovatum* the Inductive Table of Astronomy, and the Inductive Table of Optics.[5] The former begins with statements of such observations as this: "The Earth appears to be immovable." "The Stars keep their relative places in the vault of the sky, and with the Sun and Moon, rise, move, and set." It presents the successive generalizations in which these observations have been included and modified, and finally concludes with a statement of Newton's theory of universal gravitation, under which all of the preceding facts and theories can be subsumed. Similarly, the Inductive Table of Optics shows how the first facts of visually perceptible phenomena have been explained by successive generalizations, culminating with the suggestion of the undulatory theory of light.[6]

The value of the inductive tables according to Whewell is twofold. In the first place, the relevant facts are grouped so that their satisfactory inclusion under the colligating law is apparent. Moreover, the contribution of independent subordinate theories to the support of a more inclusive theory yields impressive evidence of the correctness of the latter. After asserting that the tables are comparable to the syllogism of deduction, Whewell continued:

> "And that such Tables are really a Criterion of the truth of the propositions which they contain, will be plain by examining their structure. For if the connexion which the inductive process assumes be ascertained to be in each case real and true, the assertion of the general proposition merely collects together certain ascertained truths; and in like manner each of those more particular propositions is true, because it merely expresses collectively more special facts: so that the most general theory is only the assertion of a great body of facts, duly classified and subordinated."
>
> (NOR, 115.)

[5] By "optics," Whewell meant the science which deals with phenomena which are perceptible by means of visual organs. He also spoke of "acoustics," "thermotics," and "atmology," as divisions of physics corresponding to different means of perception. This anthropocentric division of the general field of physics was generally criticized.

[6] Whewell's confidence that the undulatory theory of light conformed to all the criteria which he proposed for distinguishing a true theory would make the revival of the question of the relative merits of that and the corpuscular theory seem indefensible from Whewell's point of view.

It is true that such tables present the data, show every step of the induction, show how each proposition is included and harmonized with others in more general propositions and so present convincing evidence of the truth of the wholes, for, as Whewell pointed out, if each step is true, the whole must necessarily be sound. (NOR, 98.)

The obvious criticism is that although this schema may be adapted for the presentation of the development of any of the inductive sciences, just as the syllogism may be used for the exposition of any deductive argument, there must always be exercised an independent act of judgment concerning the validity of each step in the induction of a sort that is not necessary in following the course of a deductive argument. The whole of the latter might be diagrammed, and plotted in terms of S, M, P, with indications as to the particular syllogistic form that has been employed at each step. Then any one could supply the actual propositions. In an inductive argument, this cannot be done. The inference which follows from particular facts introduces something which is not apparent in the facts themselves; and as the first discovery of the proper inference represents a stroke of genius, it is doubtful if others could make the same leap even if the facts were selected for them. The tabular arrangement cannot reveal any certain and obvious connection between the facts and the inference; it merely makes it easier for the reader to perceive the connection which has been revealed to others in the course of their investigations. Thus the inductive table presents the relevant data and the inferences based upon them in a very simple and convincing form, but the form as such cannot guarantee the validity of the induction; it merely increases the force of the specific evidence. The inductive tables provide strong circumstantial evidence for the validity of conclusions; more cannot be done. This fact Whewell seemed to minimize when he compared the inductive tables with syllogistic forms.

The second advantage which Whewell claimed for his tabular arrangement is that it suggests the process by which any particular theory must be verified. The dependence of the theory upon certain alleged facts and subordinate theories is so clearly set forth that it becomes evident that verification of the theory involves appeal to those facts and criticism of those theories. According to

Whewell, no more formal process of verification is applicable to truths which are arrived at inductively.

Whewell consistently urged that induction must be regarded as involving a leap from facts to the relating Conceptions, and he realized that that leap can never be compressed into methodological form. However, he insisted that after the inductive proposition has been suggested, it is possible to deduce particular conclusions from it by rigorous deductive procedure. When these conclusions are seen to be in agreement with the facts, the correctness of the induction may seem to be proved. The tables show the relation between induction and deduction and suggest that inductions can be validated by the deduction from the proposed hypotheses of facts actually found by observation. Whewell insisted that this process of verification is an essential element in discovery; it is necessary to validate what might otherwise be looked upon as an unwarranted guess at the truth.

"Deduction descends steadily and methodically, step by step: Induction mounts by a leap which is out of the reach of method. She bounds to the top of the stair at once; and then it is the business of Deduction, by trying each step in order, to establish the solidity of her companion's footing. . . .

". . . Deduction is a necessary part of Induction. Deduction justifies by calculation what Induction had happily guessed. . . . Every step of Induction must be confirmed by rigorous deductive reasoning, followed into such detail as the nature and complexity of the relations (whether of quantity or any other) render requisite. If not so justified by the supposed discoverer, it is *not* Induction." (NOR, 115.)

Whewell had to acknowledge that the inductive table does not provide evidence for the conclusion that the successful colligating conception is the only one which might be applied to the facts. In fact, Whewell's critics have asserted that the tables are just as serviceable for presenting false conclusions as for presenting true ones.[7] Whewell denied that any alternative explanations have ever been proposed in place of the general propositions which explain such disparate facts as those typically included in the inductive tables. He challenged his critics "to devise any *one* other hypothesis to account for the perturbations of the moon, or the colored fringes of shadows, besides the hypothesis by which they

[7] Cf. Leuckfeld, *Archiv für Geschichte der Philosophie*, 1898. Vol. 11, p. 388.

have actually been explained with such curious completeness." (PD, 271.) His confidence that only *right* explanations could harmonize all the facts made him sure that the challenge could not be met. This appeal to fact, however, is equivalent to acknowledging that the tables do not afford formal proof of the particular proposition which is presented as the highest inductive inference, nor even of subordinate propositions.

The value of the table as an effective mode of presenting the evidence is partly due to the fact that it shows so clearly what Whewell has termed "the consilience of inductions." Frequently in the history of science, a correct theory has been found to explain facts of a different sort from those which it was originally designed to explain. For instance, Whewell cited the fact that the undulatory theory provided simple explanations of so many classes of facts,—of phenomena of reflection and refraction, of the colors of thin plates, of diffraction and of polarization,—as striking evidence of its superiority to the emission theory, which required supplementary hypotheses to make it applicable to these same facts. The present swing in favor of the latter theory makes Whewell's example seem less apt than it must have appeared at the time of its publication. It is true, however, that such coincidences would be miraculous if the theory were wholly incorrect, while they are only natural in the case of explanations which are essentially true.

In remarking this fact, Whewell appealed implicitly, we might say, to a calculation of probabilities; but explicitly his appeal was made merely to common sense. He pointed out that it is not reasonable to suppose that an explanation designed to fit one class of facts would also fit another class of facts unless it truly represented "relations among things," and was in fact "the right interpretation of nature."

> "No accident could give rise to such an extraordinary coincidence. No false supposition could, after being adjusted to one class of phenomena, exactly represent a different class, where the agreement was unforeseen and uncontemplated. That rules springing from remote and unconnected quarters should thus leap to the same point, can only arise from *that* being the point where truth resides." (NOR, 88.)

Whewell claimed that the progress of a true theory is marked by its becoming increasingly clear and simple when it is applied

to a widening range of facts. The implications of a true theory become more evident in the light of additional facts; false theories, on the other hand, require supplementary hypotheses to make them applicable to new facts. In the former case, more and more facts become intelligible in the light of the theory, which attains a maximum of simplicity and generality in the course of its verification and application to new facts; in the case of a false theory, new facts require the introduction into the general theory of new elements specifically designed to explain special groups of facts. Whewell illustrated his point by comparing the Cartesian theory of vortices with the Newtonian theory of universal gravitation, showing that in the former the copious addition of *ad hoc* hypotheses finally made of the notion of vortices merely a hypothetical machinery for producing the observed phenomena, instead of a helpful explanatory conception. (PD, 492 ff.) He gave a detailed account also of the replacement of the emission theory of light by the undulatory theory, showing how the latter has been developed and simplified, and showing how it has successfully explained new facts without requiring additional hypotheses. (HSI, II, 340 ff.) By reference to the persistent controversies between Cartesians and Newtonians, and between those who defended the corpuscular theory of light and those who championed the undulatory theory, Whewell established his observation that the course of a true theory is marked by progressive simplification and by successful explanation of new facts, while the course of theories finally rejected as false is marked by continual elaboration of the original explanation. Whewell expanded this point by showing that false theories are never rejected at once and *in toto,* but are gradually transformed until they differ from true theories only in being encumbered with unnecessary complications, which are relics of the original hypothesis and which tend to obscure the simplicity of the true explanation. The rejection of the false theory is simply the culmination of a series of partial rejections represented as modifications. Whewell's keen historical appreciation is evident in his description of this process of the transformation of hypotheses in the history of science.

"And thus, when different and rival explanations of the same phenomena are held, till one of them, though long defended by ingenious men, is at last driven out of the field by the pressure of facts, the defeated hypothesis is transformed before it is extin-

guished. Before it has disappeared, it has been modified so as to have all palpable falsities squeezed out of it, and subsidiary provisions added, in order to reconcile it with the phenomena. It has, in short, been penetrated, infiltrated, and metamorphosed by the surrounding medium of truth, before the merely arbitrary and erroneous residuum has been finally ejected out of the body of permanent and certain knowledge." (PD, 503.)

Whewell's interest in the whole process of discovery and his appreciation of the gradual change in thought through which scientific laws approach to the universality and necessity of the truths of the demonstrative sciences, gave him confidence that his tables of induction afforded a schema fitted to supply the want of an inductive logic, and also made him dissatisfied with the schemes proposed by others. (NOR, viii.) Whewell was not concerned to formulate a *logic* of induction, so much as to analyze the *process of induction.* He employed the term "induction" to designate "that process which is the essential element of the physical sciences as they now exist, and in virtue of which they are called *inductive* sciences. . . ."[8] This wide use of the term was criticized by de Morgan, who held that such an extension of the term is contrary to the most approved usage.[9] De Morgan would make induction, like deduction, a part of logic for, he said, "From Aristotle to Bacon inclusive, induction is the collection of those partial assertions which, by force of logic, necessitate the universal assertion." De Morgan suggested that Whewell realized that the term "induction," is commonly used to refer to method of discovery; also that "there is an idea that *discoveries* are made by logic." Apparently feeling obliged to follow this usage of terms, Whewell attempted to compress the whole of the method of discovery into formulae of logic, with the result that he proposed his inductive tables as comparable to the syllogism of deduction. But these tables emphasize the necessity of the introduction of new matter at each stage of induction, while the formulae of logic have always been regarded as essentially independent of the matter to which they are applied. As a logician, de Morgan could not admit the claims that Whewell made for his inductive tables. Whewell's response to de Morgan's criticism proves that his primary interest was in analyzing the whole process of discovery, and that he was relatively indifferent to the claims of logic.

[8] *Quarterly Review,* 1831. Vol. 45, p. 378.

[9] *Athenaeum,* 1859, Part I, p. 43.

"After having invited your criticism on my *Novum Organon,* I ought not to omit to thank you for it. I have been, as I expected that I should be, instructed and interested by it. Nor can I deny that it is in a great measure just. My object was to analyse, as far as I could, the method by which scientific discoveries have really been made; and I call this method *Induction,* because all the world seemed to have agreed to call it so, and because the name is not a bad name after all. That it is not exactly the Induction of Aristotle, I know; nor is it that described by Bacon, though he hit very cleverly on some of its characters, erring much as to others. I am disposed to call it Discoverers' Induction; but I dare not venture on such a novelty, except in the indirect way in which I have done. With such a phraseology I think my formulae are pretty near the mark, and my *Inductive Tables* a good invention. But I do not wonder at your denying these devices a place in Logic; and you will think me heretical and profane, if I say, *so much the worse for Logic.*" (IT, II, 416.)

As this answer to de Morgan implies, Whewell concluded that there can be no logic of induction in the sense of providing a formal schema for validating inductive conclusions without regard to the particular matter under consideration. The consilience of inductions which is clearly represented in the tables provides cogent evidence for the truth of the conclusion, but it does not afford demonstrative certainty. The further advantage of the table, that it shows clearly upon what facts the inductions are based and indicates a course of experimental verification, depends upon the *matter* which is presented in the table. The implication is clear that the evidence for the conclusion is not provided by the tabular form in which the progressive advances can be presented, but by the *facts* to which it refers. Thus the table is a convenient means of directing attention to significant data, but it cannot legitimately be regarded as having value as a logical form.

A further proof of the inadequacy of the tables from a logical point of view is the fact that the tables do not demonstrate that the final generalization is the only one that successfully colligates the facts. But, as Whewell maintained, it is essentially impossible to demonstrate that one explanation and only that one is capable of explaining all of the facts. The tables afford strong presumptive evidence for that conclusion, however, for, according to Whewell, the history of science shows no case in which a theory, finally rejected as false, has been supported by the "confluence" of various lines of evidence such as is represented in the inductive

tables. Whewell assumed that only the *right* explanations could account for all of the facts which are included in the tables. He was confident that only one finally satisfying theory can in fact be found, but he drew this conclusion from his historical survey, and he believed that it could be proved only empirically. (NOR, 90.)

Whewell's contention that successful prediction affords proof of the correctness of an inductive theory follows from his characterization of "true" theories as successful in explaining apparently disparate phenomena, as tending toward increasing simplicity, and as capable of explaining new classes of facts without the addition of supplementary, *ad hoc* hypotheses. According to Whewell, successful prediction provides proof that the theory is applicable to facts other than those which it was expressly designed to colligate. It indicates that the pattern of relations of things has been truly divined, for otherwise the correct prediction would be miraculous. (NOR, 85.)

John Stuart Mill criticized this test by successful prediction, maintaining, in contrast to Whewell, that the effect of correct anticipation of future events is psychologically striking, but of no peculiar logical cogency. In accordance with his notion that the uniformity of nature must be assumed as a principle underlying all induction, Mill protested that the success in prediction has no special significance. The principle of the uniformity of nature may be regarded as a sufficient explanation of the fact that future events, like past events, prove to be explicable by some particular law. There is no essential difference between present, past and future events. The accident of their appearing before or after the proposal of an inductive law is insignificant in comparison with the fact that all events must necessarily exemplify the uniform course of nature. Mill never appreciated Whewell's point that the successful application of the theory to new facts showed that the essential characters had indeed been understood, and that the explanatory value of the theory was not restricted in its application to the particular facts which it was designed to explain, but that it represented a *right* interpretation of those facts, and was accordingly applicable to other facts even though these differed in some respects from the particular data which provided grounds for the original induction.

Whewell could give no formal rules for the demonstration of

the correctness of inductive conclusions because he insisted that the characteristic feature of induction is the introduction of a new conception. The perfect compatibility of the new conceptions with the facts could be formally proved only by enumeration of all cases. But exhaustive enumeration is impossible. Moreover, if it were possible, it would not present the characteristic features of induction. Therefore proofs must be accepted which are not formally valid but which appeal to common sense as of strong circumstantial validity, and which in the history of science have been found only on the side of what has come to be accepted as truth. These proofs are provided in the consilience of inductions, in the simplicity and unity of the final explanation, and in success in prediction of future events.

Whewell's criticisms of the logics of Aristotle and Mill rest mainly on his conviction that these two men were so concerned to discover a method of proof for inductions that they misrepresented the process of induction itself. Whewell insisted that the important thing is, not to present the inductive conclusions when found, but to consider how they are discovered. In proposing their formal canons, both Aristotle and Mill assumed that all the elements of the discovery are ready at hand. Whewell maintained that in so far as they made this assumption, Aristotle and Mill forgot that the essence of induction lies in the *discovery* of the elements which are presented in the proof. Whewell criticized Aristotle's example of induction mainly on the ground that Aristotle neglected to consider the problem of the discovery of the middle term. Aristotle's example was faulty in other ways. "We find that several animals which are deficient in bile are long-lived, as man, the horse, the mule; hence we infer that *all* animals which are deficient in bile are long-lived." (PD, 19.) In this statement, Aristotle made the mistake of including man among the animals deficient in bile, and he omitted to observe that some animals which lack the gall-bladder are short-lived. This is not so significant, however, as the fact that Aristotle assumed in his example that the middle-term, "deficient in bile," was simply provided in the data. Aristotle was concerned only to present evidence for the conclusion that "all animals deficient in bile are long-lived." Whewell, on the contrary, insisted that the essential problem was to find the respect in which all the long-lived animals are similar. Man, the horse, and the mule agree in many other respects besides

that of being acholous, as Aristotle seemed to believe that they are. These animals show an infinity of common characters from which the one "deficient in bile" has been selected as the explanation for their being long-lived without any suggestion as to why it has been so selected. The discovery, if such it had proved to be, has been left entirely unexplained.

Credit has sometimes been attributed to John Stuart Mill for being the first to circumscribe the limits of inductive logic by restricting it to the problem of proof.[10] From Whewell's point of view, this contribution was of little value. According to Whewell, Mill missed the main problem of induction when he contented himself with proposing his logical canons. Whewell criticized Mill on the same ground that he criticized Aristotle: Mill's methods, like Aristotle's example, take for granted the previous discovery of essential connections between A and *a*, *B* and *b*, *C* and *c*, *et cetera*. Mill was not concerned with the problem of discovery. He acknowledged that his concern was only with the logical form in which the evidence must be susceptible of presentation if the induction is to be considered valid.

Whewell attempted to analyze the process of discovery; Mill was concerned with the problem of proof. Each had something to contribute to inductive logic.[11] Unfortunately, however, Whewell's contribution was almost forgotten in the enthusiasm with which Mill's views were received. Even at Cambridge, Mill's influence was much greater than that of any indigenous thinker.[12] The fact is, of course, that Mill's *System of Logic* was very widely read, and that its clarity and specious simplicity made such books as Whewell's appear laboured and unfruitful. The limitations of Mill's Four Methods were not generally recognized, and Whewell's criticisms of their inadequacies were not appreciated by his contemporaries. Almost immediately after the publication of the *Logic,* Whewell objected to instances cited by Mill as examples of successful induction. In a letter to a friend, Whewell said of Mill,

"... when he comes to Induction, he appears to me to write like a man whose knowledge is new (indeed he confesses that he had much of it from Herschel and me),—and not very well ap-

[10] Cf. above, page 88.

[11] Cf. Hibben, *Logic, Deductive and Inductive.*

[12] Sidgwick, *Philosophy at Cambridge,* Mind, 1876, Vol. I, pp. 235–245.

propriated. For instance, a great number of his examples of scientific investigation are taken from Liebig's researches on physiological chemistry—*just published*. The most profound and sagacious physiologists and chemists cannot yet tell which of these will stand as real discoveries; still less can they put these new views into the true relation to the old without long thought and study. How then should Mill do it, to whom the whole subject is new?" (IT, II, 313.)

It is a curious proof of the uncritical enthusiasm with which Mill's book was received and his tenets adopted, that the necessary rejection of these examples, foreseen by Whewell, was not generally regarded as evidence of the insufficiency of Mill's methods even though the false inductions had been cited as exemplary instances of their employment.

The controversy between Whewell and Mill apparently was dropped when popular acclaim accorded all honors to the latter, but the detailed criticisms of Whewell's views which appear in Mill's *System of Logic* show that Mill had regarded him as an opponent worthy of most careful rebuttal. Whewell answered Mill's objections and set forth his own criticisms of Mill's views in a pamphlet, printed for private circulation.[13] The material was later included as the twenty-second chapter of the *Philosophy of Discovery*. Undoubtedly Whewell was nettled by the fact that Mill accepted many of Whewell's original observations as if they were fairly obvious truths, while he attempted to destroy the other foundations of the philosophy which Whewell had developed. Whewell noted ten points of disagreement with Mill. These were of unequal significance, and it only seems worthwhile to refer to the fundamental points of dispute.

The first difference which Whewell mentioned was concerned with the meaning of the term "Induction." Mill cited as an example of induction the case of the child who, having burned himself once, shuns fire in the future. Thus, such applications of past experience to new situations as are shown by very young children and even by animals were regarded by Mill as inductions. Mill insisted that the inference from particular cases to other particular cases, without the mediation of a general proposition, must be recognized as induction. Whewell answered with the

[13] *Of Induction with special reference to Mr. J. S. Mill's System of Logic*, 1849.

counter assertion that the formation of generalizations is the essential characteristic of all induction.

Whewell criticized Mill's including superstitions as examples of induction on the ground that we cannot hope to learn anything about the discovery of new truths from studying old errors. Mill defended his position by showing that the same type of mental activity is involved in these cases as in those to which Whewell restricted the designation "induction," and that the evidence for the conclusions was of the same sort in the various cases.[14] The fundamental difference in their points of view was indicated in this question of what constitutes induction. Whewell's philosophy had been constructed on the premise that induction is the *process through which scientific generalizations are discovered.* Mill, on the other hand, contended that a study of induction involves an investigation into the *grounds of evidence for such generalizations.* Whewell was concerned with discovery, or "invention," as Mill called it, while Mill insisted that the problem of proof is the problem of induction.[15]

Kepler's discovery of the elliptical orbit of the planets was selected by Mill as an instance illustrative of the distinction which he made, and which Whewell refused to accept, between inductions and mere descriptions, which Mill regarded as subsidiary to induction. Referring to Kepler's discovery, Mill asserted that this Colligation of the Facts represented, not an induction, but merely a preliminary description, which provided data for an induction in accordance with the Method of Agreement.

"The Colligation of Facts, therefore, by means of hypothesis, or as Dr. Whewell prefers to say, by means of Conceptions, instead of being, as he supposes, Induction itself, takes its proper place among the operations subsidiary to Induction. All Induction supposes that we have previously compared the requisite number of individual instances, and ascertained in what circumstances they agree. The Colligation of Facts is no other than this preliminary operation."[16]

Mill continued his criticism of Whewell's theory by showing that the Concepts which Whewell insisted are necessarily applied

[14] *System of Logic,* Book III, chapter ii, section 1; chapter iv, section 3, note.

[15] *Ibid.,* Book III, chapter ii, section 5.

[16] *Ibid.,* Book IV, chapter i, section 4.

to the facts in induction, are really "general conceptions, or conceptions by means of which we can think generally," obtained "by *abstraction* from individual things."[17] Mill was concerned to refute Whewell's apriorism by reducing the process of discovery to the common operations of abstraction and comparison, by which facts may be found to agree with conceptions abstracted from the same or from other facts. He denied the aprioristic origin of the conception, insisting that "the conception is not furnished *by* the mind until it has been furnished *to* the mind; and the facts which supply it are sometimes extraneous facts, but more often the very facts which we are attempting to arrange by it. . . ."[18] All this mental activity Mill counted as preliminary to induction, and he asserted that he would have omitted such discussion as "irrelevant to the principles and rules by which the trustworthiness of the results of thinking is to be estimated," if Whewell's work had not "rested the whole theory of Induction upon such ideological considerations."[19] This assertion emphasizes further the fact that Mill was essentially interested only in questions of the value of evidence, while Whewell was primarily concerned with the process of discovery. Whewell believed that only by study of that process can we know what type of evidence may be legitimately demanded and what evidence has validated past discoveries.

Whewell criticized Mill's "Four Methods of Experimental Inquiry" on the ground that Mill did not show how these methods had in fact been applied in the discovery of any generally recognized principles. Moreover, Whewell asserted what posterity has agreed is the fact, that Herschel, in his earlier remarks on similar methods had shown an understanding of their limitations which Mill failed to appreciate. Herschel was much closer to Whewell than to Mill when he criticized Bacon's emphasis on types of instances, to which Mill's discussion of methods is in some respects analogous.

"The force of the instance must be felt in the mind before it can be referred to its place in the system; and before it can be either referred or appreciated it must be known; and when it *is* appreciated, we are ready enough to weave our web of induction, without greatly troubling ourselves whence it derives the weight

[17] *Ibid.*, Book IV, chapter ii, sections 1 and 2.
[18] *Ibid.*, Book IV, chapter ii, section 3.
[19] *Ibid.*, Book IV, chapter i, section 4.

we acknowledge it to have in our decisions. . . . No doubt such instances as these are highly instructive; but the difficulty in physics is to find such, not to perceive their force when found." [20]

Neither Herschel nor Whewell was willing to confine himself to the purely logical problem which Mill made his own. Both of these men were too well aware of the difficulties involved in the actual making of discoveries to feel that the question of providing a formal scheme for their validation was of comparable importance even if it had been possible. They were concerned to solve the primary mystery of how we can arrive at generalizations based upon experience, which prove to be valid beyond the limits of experience and which are safely assumed as bases for further investigation, resulting in still wider generalizations.

Herschel, Whewell and Mill were regarded by their contemporaries as the three English methodologists *par excellence,* but the contributions of the first two were soon overshadowed by the wealth of material contributed on the problems of inductive logic during the latter part of the nineteenth century. Mill's definition of the problem was generally accepted, as even Whewell seemed to acknowledge when he said in the preface to the *Philosophy of Discovery,* " the Philosophy at which I aimed was not the Philosophy of Induction, but the *Philosophy of Discovery.*" [21] But because he had first entitled his work a *Philosophy of the Inductive Sciences,* Whewell appeared to many to have failed in a task which he had not actually meant to claim as his own, and his real contributions were neglected as irrelevant to the problems of inductive logic. Only in comparatively recent times, the questions of discovery with which Whewell was primarily concerned have been recognized as of essential interest for inductive logic and as significant for the wider questions considered in the philosophy of science.

[20] *Preliminary Discourse on the Study of Natural Philosophy,* Article 192.

[21] This admission was referred to by de Morgan in the *Athenaeum,* April 14, 1860, p. 503, as a capitulation to his criticism, referred to above, page 126. Unless it is through an error that the preface to the *Philosophy of Discovery* is dated February 8, 1856, de Morgan is not entitled to this self-congratulation, for his criticism did not appear until 1859.

CHAPTER VI.

Whewell's Teleology.

Whewell aimed to arrive at a satisfactory philosophy of induction by studying and analyzing the facts about the history of science. He presented his conclusions as embodying descriptive generalizations about the process of discovery, and as establishing an epistemological dualism of *a priori* Ideas and empirical data. In order to explain the unity and coherence of a system of knowledge involving such disparate elements, Whewell had to venture into the controversial field of metaphysics. Of course Whewell cherished the conviction that his epistemological and metaphysical views were both dictated by the actual facts. The former he presented as the inevitable conclusion from the constitution of scientific knowledge as revealed in its progressive development; the latter, he considered to be an equally well assured conclusion from actual facts, further supported by his epistemological analysis. Whewell assumed the reality of an independently existing, objective universe. He assumed that man is enabled to know that external world through the *a priori,* subjective conditions of knowing. His explanation of this harmony between the subjective and objective constituents of knowledge provided additional support for the conclusion which he had already defended in the *Bridgewater Treatise;* namely, that the universe and everything in it was designedly created to satisfy the requirements of man.[1]

Whewell's attempt to provide an ultimate explanation for his observations justified men in regarding him primarily as a metaphysician. This term was already regarded by many as implying some opprobrium, but Whewell by no means shared their feeling. Comte had spoken of metaphysics as the second stage which the new Positivism was to replace, and many adopted his point of view. Whewell, on the other hand, maintained that some metaphysics has been implied in every forward step in science. (NOR, 184.) The discovery of a new relating Conception, and its explication and verification, are really contributions to metaphysics,

[1] Cf. above, page 8.

according to Whewell. Scientific controversies end by establishing a certain point of view as the *right* interpretation of phenomena. To this extent, the progress of science may be regarded as the development of a *good* system of metaphysics. Because he took this point of view, and opposed the Comtian criticism of metaphysics, Whewell was willing to attempt the justification of the metaphysical point of view which he conceived to be demanded by his empirical observations, and which he considered satisfying to the demands of the spirit, as well as fruitful in explanation.

Whewell found the ultimate resolution of all of his problems in the view that the universe has been expressly designed and created to meet the requirements of organic creatures, and particularly of man. Whewell expressed his teleological views first in the *Bridgewater Treatise,* which presented evidence for the view that the Creator took into account the nature of the elements and the needs of inhabiting creatures, and fashioned both to provide for the well-being of the latter.[2] In the *Indications of the Creator,* Whewell presented extracts from the *History* and the *Philosophy of the Inductive Sciences* which tended to support the same view. Whewell urged the point that these extracts were particularly significant because they had been composed originally without reference to the argument in connection with which they now appeared.[3] It is clear from Whewell's correspondence that the *Indications of the Creator* was intended as an answer to Chambers' *Vestiges of the Natural History of Creation* which was then widely read in England. (IT, II, 325.) Clearly Whewell's book was designed to support current theological doctrines, for it refers particularly to "Indications of Design in the Creator, and of a Supernatural Origin of the World," and incidentally to "the consistency of the Inductive with the Revealed History of the World."[4] In the third edition of the *Philosophy of the Inductive Sciences,* Whewell added three chapters[5] dealing with various aspects of the relation between science and theology. In these he repeated his original thesis, modified slightly in the direction of a more Platonic conception. In the present discussion it is interesting as indicating Whewell's final solutions to problems sug-

[2] *Bridgewater Treatise,* Book II, chapter xii, section III, for instance.
[3] *Indications of the Creator,* preface to the first edition.
[4] *Ibid.*
[5] *Philosophy of Discovery,* chapters xxx, xxxi, xxxii.

gested by his analysis of the history of science and of the process of discovery.

Whewell attempted to establish his metaphysical explanations on the same grounds that he had employed in justifying his scientific conclusions. He explained his conception of the creative design of the universe by reference to two Fundamental Ideas. These he regarded as necessary conditions of the intelligible understanding of the universe as a whole, in the same way that other Ideas were found essential for the comprehension of particular groups of facts. The first Idea, the *Idea of Final Cause,* had already been found necessary in the explanation of facts of biology. Whewell repeatedly asserted that the structure of animals can be understood only with reference to their function, to the purpose they serve in the life economy of the organism. This view he further extended to include the conception of the whole universe as purposely designed by "a living Mind, a Power which aims as well as acts." (HIS, III, 392.) This extension of the notion of Final Cause may suggest that Whewell was inclined to follow Plato in accepting a teleological explanation of all things. This, of course, is not the case. Whewell regarded the teleological explanation as providing a solution of the problems of metaphysics, but he insisted that scientific explanations must also be given to account for specific facts. Although we may appreciate the evidence of design in the adaptation of atmospheric pressure and organic requirements, for instance, we must also study the details of these conditions and determine the laws of their variations in accordance with the methods approved in the physical sciences. The *Conception of Final Cause,* like other Fundamental Ideas, is limited in its application. It is fruitful only in considering organic structures or in considering the harmony and unity of the total universe.

A second Fundamental Idea which Whewell referred to as supporting his theory of creation was the *Idea of a First Cause.* He claimed that this Idea must be assumed in the palaetiological sciences [6] if the phenomena are to be fully explained. Whewell

[6] By the "palaetiological sciences," Whewell meant "those in which the object is to ascend from the present state of things to a more ancient condition, from which the present is derived by intelligible causes." (HSI, II, 257.) He considered under this heading, "Descriptive Geology," "Geological Dynamics," and "Physical Geology."

remarked that men have persistently asked, "What was the beginning?" even though no answer has ever been forthcoming. He explained this as due to the fact that men "are impelled by an intellectual necessity." They are led on by an *a priori* conviction, which Whewell calls an "Axiom," that "there must be a First Cause." (HSI, II, 316 ff.) Reasoning founded upon this "necessary principle," Whewell regarded as possessing "the genuine character of demonstration." (HSI, II, 321.) He supplemented this premise by a conclusion that the First Cause must have been a conscious Creator, basing this conclusion on evidence drawn from the mutual compatibility of various natural conditions, and their adequacy for man's requirements. Finally, Whewell arrived at the conclusion "that the Creator of the natural world can be no other than the Author and Governor and Judge of the moral and spiritual world." (HSI, II, 323.)

Apparently Whewell believed that this conclusion was grounded in the same way as other inductively established convictions, for he incorporated this argument in the *History of the Inductive Sciences* and also in the *History of Scientific Ideas.* Whewell recognized the fact that the eternal question, "What is the beginning?" cannot be answered by mere appeal to facts, but he seemed to believe that he had legitimatized his own answer when he showed its dependence upon Fundamental Ideas. By including considerations of this problem of cosmogony as part of his *History* and *Philosophy of the Inductive Sciences,* Whewell contrived to give the impression that the belief in a Deity responsible for the creation of the universe is warranted in the same way that the accepted laws of science are warranted.

In more cautious moments, Whewell wrote as if aware that naturalistic views of the world might claim the same support as his own theological conceptions. He acknowledged that the Nebular Hypothesis involves an idea which, according to his own theory, would be regarded as a Fundamental Idea whenever all of the facts should be found to be consistent with the hypothesis. But since many facts can be cited which do not appear to be in harmony with Laplace's theory, Whewell took the position that another Idea had at least equal claims to acceptance, namely, "the Idea of Man as the principal Object in the Creation; to whose sustenance and development the other parts of the Universe are subservient as means to an end. . . ." (PD, 305.) Although

Whewell made this formal acknowledgment of the possibility of admitting an alternative view, he clearly gave all the weight of his own authority to the support of the supernaturalistic view of the origin of the universe.

Undoubtedly the real motive behind Whewell's including this metaphysical discussion with his writings on the inductive sciences was his desire to establish on the firmest possible ground, a conviction which he could not bring himself to part with, but which he realized was being shaken by the scientific contributions of Lyell, which was soon further endangered by Chambers' popular *Vestiges of the Natural History of Creation,* and which was finally undercut by Darwin's proof of the evolution of species. Whewell realized that scientific progress frequently necessitates a revision of the popular interpretations of the biblical accounts of creation *et cetera,*[7] but he found it very difficult to appreciate the evidence in support of any proposition which would necessitate changes in his own theological conceptions. This was evident in his criticism of Lyell's theory of uniformitarianism, in his defence of Cuvier's doctrine of the fixity of species, which accorded so well with the argument from design, and in his reluctance to accept Darwin's proofs of the evolution of species. This inability to appreciate the force of evidence which endangers a long-cherished view is not uncommon. In Whewell's case it is remarkable only because his defence of his convictions indicates the way in which his apriorism may be made to furnish support for a theory which is really treasured because of its emotional value. Whewell found ground for his theological convictions in the *Idea of a First Cause* and in the *Idea of Final Cause*. By reference to these *a priori* Fundamental Ideas, as he considered them, Whewell seemed to find a rational justification for his faith that the universe is the product of creative design. This theory of creative design had an important part in the ultimate solution of Whewell's epistemological problems, for it enabled him to weave into a superficially coherent whole his various realistic, idealistic, and rationalistic tenets.

Whewell's doctrine of the Fundamental Antithesis divided knowledge into objectively determined factual content and subjective *a priori* form. Knowledge, Whewell asserted, represents an harmonious combination of these two independently given elements. The notion that knowledge depends upon an unconscious

[7] Cf. HSI, II, 297 ff.

synthesis of facts and Ideas was proved to Whewell's satisfaction by the possibility of analyzing knowledge into these two factors. That such an analysis is possible he had demonstrated by his division of the history of science into a history of the discovery of new facts (HIS), and a history of the discovery of new conceptions applicable to the facts. (HSI.) Such evidence in support of a theory might have been sufficient for another man, but Whewell was too much of a metaphysician to leave the problem in this state. He admitted the legitimacy of the question: how is it possible that *a priori* forms of thought are applicable to the data presented by an external universe? and he undertook to provide an answer by referring to his teleological conception of the universe. The appropriateness of the Fundamental Ideas to the facts whose intelligible relations they reveal is explained by postulating a pre-established harmony between them. The Ideas once discovered are seen to fit the facts because they were originally designed to fit them. The Creating Deity planned their mutual compatibility with beneficent foresight. This is the first resolution of the problem which Whewell's teleological conception suggested.

In the last three chapters of the *Philosophy of Discovery,* which first appeared in that volume, Whewell suggested a more idealistic solution of his epistemological dualism. He retained the notion of a pre-established harmony between facts and Ideas, for which the beneficent Creator of all things was considered to be responsible, but he introduced the notion that the Fundamental Ideas of man are imperfect copies of the Divine Ideas in accordance with which the world was ordered. The universe is looked upon, not so much as a product of the simple *fiat* of the Creating Deity, but rather as an embodiment of Ideas in the mind of God. Man can know the real universe because his Fundamental Ideas resemble in essentials the Ideas in the Divine Mind which are also represented in the laws of the physical universe. The inadequacies in our comprehension are due to the fact that our Ideas never attain the perfect lucidity of the Divine Ideas, but are merely imperfect copies of them.

"... these Ideas of the human mind are also Ideas of the Divine Mind according to which the universe is constituted. Man has these thoughts, and sees them verified in the universe, because God had these thoughts and exemplified them in the universe.

"But of all these Ideas, I should also have to remark, that the

way in which man possesses them is immeasurably obscure and limited in comparison with the way in which God must be supposed to possess them." (PD, 371.)

Whewell compared this notion of the correspondence between our Ideas and their prototypes in the Divine Mind to Plato's Theory of Ideas. (PD, 359 ff.) He admitted a striking similarity between his own conclusions and those of his Greek predecessor. He pointed out as the one essential difference the fact that Plato seemed to admit into the number of Ideas, ideas of tables, of triangles, and of such particular things. Whewell, on the other hand, restricted Ideas to those fundamental general notions like the *Idea of Space* and the *Idea of Cause,* from which "flow real and universal truths." (PD, 365.) On the whole, he developed his argument from design into an explanation which he recognized as essentially Platonic. Following Plato, and introducing a conception from Christian theology, Whewell asserted that Ideas in the Divine Mind are "realized as part of the fundamental constitution of the universe" (PD, 363) and account for its intelligibility.

This resolution of his problem which Whewell adapted from Plato in order to explain the intelligibility of a universe whose real and independent existence he never doubted, is similar to the ultimate explanations which Idealists, from Plato to Royce, have hit upon. Berkeley explained the persistent existence of things on the ground that they are eternally perceived by God, who is responsible also for the uniformity with which certain ideas succeed certain others in our minds. Royce conceived God as a Being in whom the divorce between fact and idea is entirely overcome, so that "he simply sees his ideas fulfilled in the facts of his experience, and beholds his experience as the fulfillment of his ideas." [8] Whewell was forced to resolve the dualism between facts and Ideas as elements of knowledge by resorting to the same postulate of a responsible Creator, who has chosen to enable man to view the universe as orderly and intelligible. This solution has usually been associated with the idealist tradition, but Whewell's rationalistic premise seemed to require a similar conclusion even though he professed a realistic view of science.

In an earlier chapter,[9] it has been pointed out that Whewell

[8] Royce, *The Conception of God,* New York, 1909, p. 10.

[9] Cf. above, page 32.

refused to follow the post-Kantians to their idealistic conclusions. (PD, 300 ff.) Moreover, Whewell refused to accept certain views expressed by Kant himself. He criticized Kant on the ground that Kant disregarded the fact that the empirical data are determined in some respects independently of the mind. In his emphasis upon the contribution to knowledge made through the forms of perception and the categories of the understanding, Kant minimized the importance of the *matter* which is apprehended only as conditioned by the forms and categories. Carrying out the figure suggested by Kant's comparison of his own revolutionary notion with that of Copernicus, Whewell objected that Kant's view failed to explain how precise scientific determinations are possible.

"So Kant conceives that our experience is regulated by our own faculties, as the phenomena of the heavens are regulated by our own motions. But accepting and carrying out this illustration, we may say that Kant, in explaining the phenomena of the heavens by means of the motions of the earth, has almost forgotten that the planets have their own proper motions, and has given us a system which hardly explains anything besides broadest appearances, such as the annual and daily motions of the sun; and that Fichte appears as if he wished to deduce all the motions of the planets, as well as of the sun, from the conditions of the spectator;—while Schelling goes to the origin of the system, like Descartes, and is not content to show how the bodies move, without also proving that from some assumed original condition, all the movements and relations of the system must necessarily be what they are." (PD, 313.)

In criticizing those aspects of Kant's view which were regarded by his German successors as the necessary consequences of his general position, Whewell announced that he refused the idealistic solution of the problems which were raised by his dualistic epistemology. Our general points of view, Whewell believed, are consequences of our mental make-up, of the *a priori* conditions under which we necessarily perceive and understand. The particular determinations of these Ideas, however, must be learned through experience. So far as we can see, there is no rational necessity determining the precise relations between mass, distance, and attractive force, for instance. These relations are learned empirically. The actual constitution of things dictates these quantitative determinations. In accordance with his view that knowledge is

real because it refers to relations between things (PD, 480), Whewell insisted that the element in experience which is determined by acquaintance with actual things and events is no less essential than the Ideas under which those things and events are necessarily perceived. In opposition to the Hegelian view that only the rational is actual, Whewell maintained that the empirical matter of knowledge is as necessary a constituent of science as the *a priori,* ideal element.

When the emphasis is put upon the process of the "idealization of facts" by which "that which was a part of the objective world becomes also a part of the subjective world" (PD, 301), Whewell's theory appears to approach idealism with its notion that subjective conditions determine experience and that consequently nothing can be known of the hypothetical objective determinants of experience except as they are revealed *in* experience, that is, as subjectively conditioned. Indeed, one might well say that Whewell's whole theory of the Fundamental Antithesis is merely an assertion of that point. On the other hand, however, Whewell always insisted that science represents a right interpretation of the existing universe. Science is knowledge, Whewell maintained, because it involves subjective, rational elements in the Fundamental Ideas which are applied to the facts. Science is *real* knowledge only because it truly represents the actual order of independently existing things. (HSI, I, 49.) Thus Whewell showed a curious mingling of idealism and realism in his general view, the first as a consequence of recognition of an *a priori* element in knowledge; the second as a consequence of his conviction that the nature and history of science, and the process by which science develops, all contribute to establish the view that science is, as it claims to be, the right interpretation of nature. The explanation of this harmony of subjective and objective constituents in knowledge is to be found, according to Whewell, not in their original unity in an idealistic Absolute (PD, 308), but in the original design of the creating deity. Whewell seemed to believe that this explanation involved a much less extravagant venture into the realm of the essentially unknowable than the explanation which the German Idealists offered. (PD, 309 ff.)

Whewell rejoiced in this solution because it seemed to provide a means of harmonizing the medley of realistic and idealistic, and rationalistic and empiricistic elements which were combined in

his philosophy of induction. His belief that there is a real, external world to be known was taken account of in the explanation that the laws of the real universe exemplify the ideas of God. The notion that the external world can be perceived and understood only in accordance with the *a priori* conditions of the understanding is harmonized with the realistic faith that we really do know the external world by the postulate that the laws of the external world and the *a priori* Ideas of man are both expressions of Ideas in the Divine Mind. Similarly, the rationalistic view that nature is intelligible only in the light of the *a priori* element in knowledge, is provided for in the notion that the Fundamental Ideas in the light of which phenomena are seen to be intelligibly related are *a priori* in the human mind. It cannot be wondered at that Whewell was reluctant to submit to criticism a view which seemed to harmonize his diverse positive contentions so satisfactorily.

Whewell suggested that there are two possible solutions to the problems raised by his theory of the dual constitution of knowledge. The first, the empiristic view that the ideal elements are originally derived from experience and are applicable to things because they have their original source in acquaintance with things, Whewell left for his opponents to defend and to develop. He was concerned to point out the consequences of what he proposed as an alternative view: that the compatibility of the facts and the appropriate Ideas is due to the foresight and design of a "Supreme Creative-Mind," and "that the truths which exist or can be generated in man's mind agree with the laws of the universe, because He who has made and sustains man and the universe has caused them to agree. . . ." (PD, 358.)

The supernaturalism which was so thoroughly bound up with Whewell's explanation is no longer acceptable. If his aprioristic premises and his Kantian idealism are to be successfully combined with his scientific realism some modifications of his views must be suggested. Since the empirical tradition is obviously incapable of explaining what is claimed by the rationalists to be the fact: namely, that there are certain criteria of reason to which the *dicta* of experience must conform, the rationalists seem compelled to maintain some form of the dualism which Whewell represented by the Fundamental Antithesis between Ideas and sensations. The problem of the relationship between knowledge of the real

and permanent, and experience of the phenomenal world, has been a persistent problem for the rationalists since it was introduced by Parmenides and by Plato. Thoroughgoing empiricists can resolve it by maintaining, in agreement with some of Whewell's contemporaries, that the knowledge which the rationalists suppose to transcend the limitations of empirical knowledge is in fact derived from experience, and that its supposed universality and necessity is an illusion which is due to mere habit. Those who agree with Whewell in accepting the rationalistic premise are required to show what it is to which they attribute a priority to experience, and they are called upon to defend the thesis that this element of knowledge cannot have its origin in experience even though it is recognized as compatible with empirical findings. A review of some recent contributions to the solution of this problem reveal the rich suggestiveness as well as the limitations of Whewell's observations.

Whewell's notion that the world was designedly created so that the real order of things could be truly represented in the light of man's *a priori* ideas does not appeal to the modern reader who considers knowledge from a naturalistic and evolutionary point of view, and who tends to be impressed with the *development* of scientific conceptions rather than with their certainty and permanence. Whewell's suggestion, however, represents one of the traditional solutions of the difficulty. Besides his notion of pre-established harmony, at least two other types of solution are possible: an assertion of identity between reality and reality-as-known; and a belief that rational demands and physical nature have evolved from a common point of origin.[10] These last seem to offer more possibilities of interpretation in consonance with modern views of science, if we may judge by the fact they are defended in America today by keen critics in the Neo-Realist and Critical Realist schools, respectively. Whewell, however, was precluded from accepting either of the last solutions by the idealistic element in his fundamental premises. His contention that "science is the idealization of facts" represents an appreciation of certain idealistic contentions of the sort that Neo-Realism specifically opposes. Whewell's belief that facts are transformed when they are seen from a new point of view and in the light of a new Idea is in direct opposition to the view of those who main-

[10] Cf. Rougier, *Les Paralogismes du Rationalisme,* Paris, 1920.

tain that the object is not changed by the entering the relation "being known." Moreover, Whewell's theory of the Fundamental Antithesis is the basis for an epistemological dualism which could not be replaced by a monism of the Neo-Realist type without a denial of Whewell's entire theory of knowledge and rejection of his analysis of the process of discovery.

The second possibility of solution is the view of those contemporary realists who are epistemological dualists, but who attempt to explain the coherence of the empirical and the rational elements in experience from a naturalistic and evolutionary point of view. If Whewell was as far from them as from the Neo-Realists, it was largely because of his theological preconceptions and his lack of appreciation of the evolutionary point of view.

The fundamental principles proposed by Enriques at the Philosophical Congress of 1921,[11] indicate the revisions to which traditional rationalism must submit in order to maintain its place in the conflict with empiricism. Whewell's position was clearly incompatible with these more modern interpretations on several points. Enriques pointed out that the development of the non-Euclidean geometry shows that the choice of the Euclidean geometry was not determined by an *a priori* predilection for the Euclidean conception of space, but by the fact that that view seemed to provide explanations of maximal simplicity and intelligibility. Moreover, he called attention to the fact that criticism of the Euclidean geometry has been inspired by physical considerations, so that it no longer appears justifiable to regard geometry as prior to and independent of physics. Both of these criticisms point to fundamental limitations in Whewell's theory. His doctrine of the Fundamental Ideas implies that the *a priori* conditions of knowledge determine man to view all things in the light of specific appropriate Ideas and Conceptions. He regarded the *Idea of Space* which is developed in the Euclidean geometry as providing the one and only means of interpreting the spatial aspects of the universe. Furthermore, Whewell had no conception of the backward reference of new discoveries, and he regarded all gains as final conquests in the realm of truth which no criticism could conceivably discredit. (NOR, 32.) Even his theory of the transformation of hypotheses was developed in ac-

[11] Enriques, *La théorie kantienne des jugements à priori par rapport au développement historique de la science contemporaine, Congrès des Sociétés Philosophiques,* Paris, 1921, pp. 252–261.

cordance with his notion that when the appropriate Idea has been discovered, all partial truths are reinterpreted and are incorporated in the new theory in final, satisfying form.

Enriques remarked that such criticism of accepted theories as the twentieth century has seen advanced, indicates the need for a dynamic conception of rationalism. Such a view would recognize the fact that the *a priori* conditions of knowledge are really ideals of rationality, providing bases for judging which is the more satisfying among rival theories. Rationalism must maintain only that there are certain criteria for judgment between alternative views, and that there are certain *a priori* ideals of explanation; it cannot presume to establish the final validity of any particular point of view. This statement of the dynamic interpretation reveals the fact that Whewell's notion was essentially static. In spite of his appreciation of the gradual approach to "true" theories, and of the progressive idealization of brute facts which the progress of science has involved, Whewell limited his conception of the possibilities of scientific advance when he believed that each great discovery has provided the essentials for the final solution of a range of different problems. From Whewell's point of view, the discovery of the appropriate Idea marks the climax of the inductive process in that particular field. After the discovery of the Idea, verification and development of the conception are in order, but the science may be regarded as established on grounds which enable it to approach the "pure" deductive sciences in form and certainty. Whewell based his theory upon a view which modern rationalism rejects; namely, on the notion that the *a priori* conditions of knowledge enable man to attain to an intelligible view of the universe only because they constitute a series of Ideas in the light of which particular sets of data can be seen to be intelligibly related.

Because he believed that the *a priori* conditions of knowledge provide specifically for the understanding of various classes of phenomena, Whewell had to explain the perfect harmony between them. Denying the evolutionary notion that the universe might have become what it is through a process of natural development, Whewell was unable to give a naturalistic explanation of the compatibility of the mental equipment of man and the complexities of the physical universe. He believed that the *a priori* Fundamental Ideas, like the laws of nature, were coeval with the beginning of all

things. The theory of providential creation really aggravated the difficulty at the same time that it provided what Whewell regarded as a satisfactory solution. However, as Whewell had little appreciation of the genetic type of explanation, he probably would have considered the naturalistic, evolutionary explanation as no explanation at all.

Whewell's *History of the Inductive Sciences* suffered under the disadvantage of appearing just before the promulgation of revolutionary theories in several fields of science. His *Philosophy* was limited by the same circumstance. Evolutionary theories were not yet current. Few pious men found it necessary seriously to question the doctrines of special creation and providential design. Within a quarter century, however, even such staunch defenders of the old faith as Whewell, had to acknowledge the force of the new arguments. The reluctance with which Whewell listened to those newer theories which seemed to discredit his theological doctrines and their comfortable provision of ultimate explanations, is indicated in his regretful remarks to Professor Forbes, written in 1864:

"I have myself taken no share in the discussions on the antiquity of man; but I will not conceal from you that the course of speculation on this point has somewhat troubled me. I cannot see without some regrets the clear definite line, which used to mark the commencement of the human period of the earth's history, made obscure and doubtful. There was something in the aspect of the subject, as Cuvier left it, which was very satisfactory to those who wished to reconcile the providential with the scientific history of the world, and this aspect is now no longer so universally acknowledged. It is true that a reconciliation of the scientific with the religious view is still possible, but it is not so clear and striking as it was. But it is weakness to regret this; and no doubt another generation will find some way of looking at the matter which will satisfy religious men. I should be glad to see my way to this view, and am hoping to do so soon." (IT, II, 435.)

As a matter of fact, Whewell probably found more difficulty than most men in modifying his religious views, because he had incorporated them so thoroughly into his philosophy, even appealing to them for a solution of his epistemological problem.

Whewell's teleological explanation appears to be inevitably suggested as a necessary consequence of his apriorism. The question

may be raised whether Whewell's appeal to the conception of a designed harmony between the *a priori* conditions of knowledge and the actual order of things followed from his inability to formulate a dynamic conception of apriorism, or whether the appeal to some harmonizing principle is required by all forms of apriorism. Whewell had not transcended the limitations of the conceptions prevalent in the first half of the nineteenth century. He thought of the progress of science as depending upon the discovery of new Ideas. He believed that the rational elements of future science must be thought of as *a priori* and implicit in the minds of men, waiting only for the intuition of genius to make them explicit. The view which is taken by such men as Lalande, Enriques and Cassirer, who are now defending various versions of apriorism, is essentially different. They think of the *a priori* element in knowledge as providing norms for explanation. Decisions between rival theories are based on the *a priori* demand that the favored explanation shall yield a maximum of intelligibility according to our standards. Our conceptions are continually being revised to take account of newly discovered facts and to meet the *a priori* requirements of reason. The *a priori* determinants of experience do not provide the pattern of the fabric of our experience so definitely as Whewell supposed; but they provide norms by which we judge between alternative interpretations of experience.

This modern revision of rationalism makes difficulties which faced Whewell less glaring. The gap between subjectively and objectively determined elements in experience is certainly lessened by ascribing to the *a priori* element only a normative function. The modern version of Whewell's ultimate problem might be expressed by the question, "How is it that explanations which best satisfy the demands of reason are those which include in their scope the greatest array of facts and which also provide for the successful prediction and explanation of future events?" The assertion that these explanations satisfy the demands of reason *because* they coherently interpret the largest possible mass of facts does not solve the ultimate problems to which Whewell sought an answer.

Whewell's solution of the dualism of *a priori* and empirical elements in knowledge was designed to solve his own version of this problem. In the light of the more sophisticated discussion of the

present day, with the emphasis on the evolution of concepts and even of logical principles, Whewell's explanation seems decidedly naïve. A consideration of some recent pronouncements on the same question seems to indicate, however, that Whewell faced squarely and explicitly a problem which has not yet been settled, but merely disregarded. Whewell's effort to resolve the epistemological dualism which followed from his analysis of knowledge into the empirical and *a priori* elements, appears to offer a solution to a difficulty which later rationalists have disguised by their reinterpretation of the part played by the *a priori* element in knowledge.

A brief reference to some recent writers will suffice to establish the point that Whewell's teleological solution, although born of nineteenth century conceptions and incapable of long surviving them, has not been replaced by any that seems more generally satisfying. Lalande's theory of *la raison constituante* and *la raison constituée* represents an attempt to bridge the gap between the empirical and the rational elements in science by the mediation of a new *tertium quid, la raison constituée*.[12] This, however, must be regarded as an exemplification of the combination of the empirical and rational elements of knowledge, rather than as an explanation of the possibility of such combination. Cassirer states that "however much logic limits itself to the 'formal,' its connection with the problems of being is never broken. It is the structure of being with which the concept and the logically valid judgment and inference are concerned.[13] This represents an assertion of the fact which Whewell attempted to explain by reference to his teleological conceptions, but it does not provide a solution of the questions which that fact suggests. In the positivistic spirit, Cassirer refused to probe into such metaphysical puzzles; he is content to state the fact. I have already referred to Enriques' paper presented at the Congress of Philosophy in 1921.[14] In that brief statement of the essentials of his position, he suggested that reason merely provides logical criteria in accordance with which the facts may be represented by systems of concepts.

[12] Cf. *Revue des Cours et Conférences,* April 15 and 30, 1925. Vol. 26, Part II, pp. 1–12; 97–111.

[13] *Substance and Function,* Swabey and Swabey, translators. Chicago, 1925, p. 112.

[14] Cf. above, page 115.

Enriques' view, like Cassirer's, suggests a conception in which the agreement between logical requirements and experimental findings is presupposed, and he attempts no justification of this position beyond reference to the fact as he describes it.

A recent writer in *Mind,* discussing "Problems Raised by the Kantian *a priori* in Knowledge," [15] considers the problem of the part played by the universals of thought in the organization of experience. He takes the realistic position which Whewell had taken, asserting that "the mind's act of universalizing stands for the mode in which it construes its data, and cannot constitute the data themselves; for these in the end are not facts in our mind or facts which exist only for our mind." [16] The writer tries to take full account of the realistic faith that science presents knowledge about the independently existing universe, as well as of the organizing function of thought, and he is led to a conclusion which sounds like a restatement of Whewell's teleological view modified in accordance with the naturalistic and evolutionary theories which have definitely replaced Whewell's notion of special creation: "That the process of the mind and the order of nature conform to one another has its ground in the teleological structure of the universe which includes all orders of reality. The realm of conceptual thinking is of a higher order than the realm of existence, but there is an inner adaptation of the one order to the other." [17] This recent statement clearly suggests the limitations as well as the fruitfulness of Whewell's conception. Whewell undertook to solve the problem which was raised by his epistemological dualism and by his attempt to satisfy what he regarded as the legitimate contentions of the rationalistic, idealistic, and realistic schools, respectively. The sophisticated rationalism of today for the most part avoids the problem which Whewell naïvely exposed. Is it because the intervening progress of thought has not provided for a solution essentially different from the teleological view proposed by Whewell?

Whewell's conclusion, however dogmatic and out-grown it may seem to the modern reader, provided a means of harmonizing the several views which Whewell believed that the facts compelled an unprejudiced observer to admit. Unlike many of his contempo-

[15] G. Galloway, *Mind,* 1927. N. S., Vol. 36, pp. 306–325.
[16] *Ibid.,* page 324.
[17] *Ibid.,* page 325.

raries, Whewell avoided the extremes of realism and idealism, and he recognized the limitations of the popular empiricism championed by John Stuart Mill. His moderate position enabled him to appreciate aspects of the problems of a philosophy of science which were neglected by many of his contemporaries, but which have been recognized by more recent writers. Whewell's apriorism is no longer acceptable in the form in which he presented it. Naturalism and evolutionism have shown the inadequacies of such a view as Whewell defended, and have suggested revisions of the rationalistic view which involve essential changes in the concept of the *a priori*. The philosophy of science which Whewell elaborated in connection with his survey of the history of science represented an attempt to present a well-grounded rationalistic interpretation of the nature of science and of the processes which are involved in its development. Since Whewell wrote, revolutionary criticisms of what he regarded as perfectly certain bodies of truth have revealed the limitations and inadequacies of Whewell's conception of *a priori* Fundamental Ideas, and have given rise to the newer interpretation of rationalism which regards reason as normative, not constitutive. Whewell's philosophy of induction, like Bacon's, may be regarded as limited by the fact that at the time he wrote, subsequent revolutionary advances were not yet foreseen. Whewell's method of attacking his problem was certainly admirable, for, like modern critics of science, he sought to learn from the history of science itself what it implies about theories of knowledge and metaphysics. Through his teleological conception of the universe, Whewell found a way to harmonize the various idealistic, realistic, and rationalistic implications which his historical survey compelled him to recognize. If his conceptions are in many respects false, and if recent progress of science has revealed the inadequacies of his views, there is still much to be learned from Whewell's philosophy of science. His final solution, unsatisfactory as it is, emphasizes the problems with which any rationalistic view of science ultimately has to contend, and also indicates the difficulties of solving satisfactorily any epistemological dualism which results from an endeavor to harmonize the positive contentions of realists and idealists.

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VITA.

Marion Rush Stoll was born March 24, 1902, at Lakewood, Ohio. She was prepared for college at Lakewood High School. In 1920, she matriculated at Oberlin College, where she received the degree of Bachelor of Arts in 1924. The Adelia A. Field Johnston Fellowship was awarded to her from Oberlin College for 1925–1926. As Scholar in Philosophy at Bryn Mawr College, 1924–1926, and Fellow in Philosophy, 1926–1927, she studied with Dr. Theodore de Laguna, Professor of Philosophy, Dr. Grace Andrus de Laguna, Associate Professor of Philosophy, Dr. James H. Leuba, Professor of Psychology, and Dr. Clarence Errol Ferree, then Professor of Experimental Psychology. The degree of Master of Arts was granted to her by Bryn Mawr College in 1926. She was psychological examiner at the Syracuse State School, 1927–1928, and studied with Dr. Floyd H. Allport, Professor of Social and Political Psychology at Syracuse University. During 1928–1929, she assisted in the Department of Psychology at the University of Michigan, and studied with Dr. Walter B. Pillsbury, Professor of Psychology, Dr. John F. Shepard, Professor of Psychology, and Dr. Roy Wood Sellars, Professor of Philosophy.

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